Ohio Department of Natural Resources

COASTAL ZONE INFORMATION CENTER

RESOURCES

OF THE

LAKE ERIE ISLAND REGION

CZM
Ohio Coastal Zone Management Program

RESOURCES OF THE LAKE ERIE ISLAND REGION

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INTRODUCTION TO THE RESOURCES OF THE LAKE ERIE ISLAND REGION

Lake Erie has been described as the busiest, most traveled and most important lake in the world (Ross, 1949). While this description emphasizes the commercial importance of the lake, its importance to the people of Ohio extends far beyond these narrow boundaries. This report outlines the diverse opportunities the lake, and, more specifically, its island region, offers Ohioans. Most importantly, the recreational, educational, and esthetic features of this region are unique in the state and offer possibilities for personal growth and development to the greater community residing throughout Ohio.

Ohio's jurisdiction of Lake Erie covers approximately 3527.5 square miles of surface area. Within this jurisdiction are a number of islands and rocky outcrops covering an approximate area of 10.5 square miles (6736 acres). Of Ohio's 262 miles of Lake Erie shoreline, 43.2 miles are island shoreline. These islands are concentrated entirely in the western basin of the lake and contribute to the shoreline of Lucas, Ottawa, Sandusky and Erie Counties. Island shoreline and area information are presented in Tables 1 and 2.

Islands are formed by a variety of processes. Ohio's Lake Erie islands are rocky outcrops that were more resistant to erosion by ice and water than the surrounding land during Pleistocene glaciation. Due to changing water levels, islands have their ups and downs. Gull Island, north of Kelleys Island, is a rocky outcrop only when the lake level is two feet or less above International Great Lakes Datum (Lake Erie = 568.6 ft.). When lake levels are high, only Gull Island Shoal exists. Legal definitions of an island are based on court decisions and, in general, follow the dictionary definition (Baldwin, 1965).

a. Body of land entirely surrounded by water
   Busch v. Wilgus
   24 Ohio N. P. (n.s.) 209

b. A body of submerged land though covered by an aquatic vegetation is not an island.
   Webber v. The Pere Marquette Boon Co.
   62 Mich. 626, 30 N. W. 469,472

c. In determining whether a formation in a river is an island or part of the shore land, account should be taken of the size and stability of the formation, its physical features and the relative size and permanence of the channels around it
   McBride v. Steinweden
   72 Kansas 508, 83 p. 822,824

TABLE 1

OHIO ISLANDS IN LAKE ERIE

Island	County	Shore Length (Statute Miles)	Area	
			Sq. Miles	Total Acres
Ballast	Ottawa	0.7	-	12
Catawba	Ottawa			
East Harbor		6.6	1.41	902.4
West Harbor	Ottawa	5.9	0.64	409.6
Middle Harbor	Ottawa	3.7	0.42	268.8
Gibraltar	Ottawa	0.5	-	6
Green	Ottawa	0.8	-	17
Horseshoe	Ottawa	0.8	-	
Johnson	Ottawa	3.3	0.45	288
Kelleys	Erie	11.4	4.37	2797
Middle Bass	Ottawa	7.7	1.27	813
Mouse	Ottawa	0.5	-	5
North Bass	Ottawa	5.2	1.10	704
Rattles	Ottawa	0.05	-	< 1
Rattlesnake	Ottawa	1.6	0.10	60
South Bass	Ottawa	10.7	2.45	1570
Squaw	Sandusky	0.2	0.005	3.2
Starve	Ottawa	0.2	-	< 1
Sugar	Ottawa	0.9	-	40
Turtle	Lucas	0.1	-	< 2
West Sister	Lucas	1.3	0.12	80

TABLE 2

SHORELINE AND AREA DATA OF WESTERN LAKE ERIE IN OHIO

County	Total Mainland Shore Length	Total Island Shore Length	Total Island Area		Total Lake Erie Area		Total Sandusky Bay Area	
			Sq. miles	Acres	Sq. miles	Acres	Sq. miles	Acres
Lucas	23.0	1.7	0.41	262.4	257.21	164,614.4	-	-
Ottawa	51.0	24.0	5.74	3673.6	291.04	186,265.6	24.42	15,628.8
Sandusky	5.0	0.2	0.005	3.2	-	-	5.64	3,609.6
Erie	41.0	11.4	4.37	2796.8	1342.09	218,937.6	27.14	17,369.6

Data Sources:

Sherman, C.E. 1933. Ohio Topographic Survey: Final Report. Columbus, Ohio, Ohio State University Press.

U.S. Lake Survey Charts of Lake Erie

U.S. Geological Survey, Topographic Maps of Ohio

d. If land originated as islands in navigable streams, even if they may have ceased to be islands, are to be considered such.
Steckel v. Vancil
92 Kansas 591, 141 p. 550

e. A tract of land can be defined as an island even if artificially cut off by channel from the mainland, yet title resides in owner before being cut off.
State v. Barco
150 North Carolina 792, 65 S.E. 673, 675
Citing 23 Cyc 357

f. "Island" means a rock or land elevation above the waters of Lake Erie having an area of five or more acres above water.
Chapter 1531.01 (CC) Ohio Revised Code

g. "Reef" means an elevation of rock, either broken or in place, or gravel shown by the latest United States Chart to be above the common level of the surrounding bottom of the lake, other than the rock bottom or in place forming the base or foundation rock of an island or mainland and sloping from the shore thereof. A reef also means all elevations shown by such chart to be above the common level of such sloping base or foundation rock of an island or mainland, whether running from the shore of an island or parallel with the contour of the shore of an island or in any other way, whether formed by rock, broken or in place, or from gravel.
Chapter 1531.01 (DD) Ohio Revised Code

h. "Channels and passages" means those narrow bodies of water lying between islands or between an island and the mainland in Lake Erie.
Chapter 1531.01 (BB) Ohio Revised Code

The Ohio Revised Code does not define the term "shoal". U.S. Lake Survey charts use the terms reef and shoal for similar topographic features and are considered synonymous in this report.

The Ohio Coastal Zone Management Program was developed as a result of the Coastal Zone Management Act of 1972 (P. L. 92 - 583). During the first year of effort, the program identified the land/water interface of the nine coastal zone counties of Lake Erie along with their associated wetlands, bays, and estuarine areas as its principal concern. Of the issues and problems associated with the Ohio coastal zone interface, a number specifically concern the islands. Of specific concern are the following (ODNR, Coastal Zone Management Program, 1st Yr. Rpt., 1976):

1. the lack of information on the Lake Erie islands
2. public versus private development of the Lake Erie islands
3. transportation problems associated with the Lake Erie islands
4. lack of information on the ecological systems and significance of Sandusky Bay
5. problems associated with agricultural runoff: 1) silt and sediment runoff; 2) nutrient runoff

The purpose of this report is to respond to the specific issues and problems associated with the Lake Erie islands by providing basic information and an environmental analysis of the island region. For the purposes of this report, an environmental analysis means studying Ohio's island region as a natural ecosystem with the understanding that the natural elements which compose the region also have a social value. Descriptions and discussions of the biological and geological resources, erosion hazard areas, recreational areas, economic status and opportunities, cultural features, historic events and places of the islands and the surrounding island region are provided. Particular emphasis is placed on the identification of "critical" resource areas. These are resources judged to be of "critical" importance due to their scarcity or economic value. Due to their lack of protection and vulnerability to development, the Ohio Department of Natural Resouces is committed to guiding the management of such areas on a statewide, local, and individual citizen basis. The goal of this currently evolving guidance effort is the encouragement of orderly economic growth and preservation of such critical resources (ODNR, Critical Resource Areas: ODNR Policy, 1977). In a given region, prime agricultural land, commercial mineral strata, flood plains, forest land, hazardous geological formations, points of significant aquifer recharge, scenic rivers, natural areas or wetlands may be deemed "critical" areas. In the island region, natural areas and wetlands are of particular interest for consideration.

This report presents the findings of extensive investigations and studies of the island region of western Lake Erie. A limited number of previous reports have attempted comprehensive reviews of the island region. Usually, only a few islands served as the focal point of interest, e.g., THE MASTER PLAN OF THE ERIE ISLANDS STATE PARK (Behnke, Dickson & Tkach, 1974). The latter covered Green Island, Kelleys Island and South Bass Island.

The following investigations have been made as part of this study.

1. An inventory and evaluation of published information relating to the islands have been performed. The information base is scattered throughout professional journals, periodicals, books and reports by local, state, federal and Canadian provincial and federal agencies. Sources for this inventory included The Ohio State University libraries, the CLEAR research library, and public libraries in Port Clinton, Sandusky, and Toledo, Ohio. This search revealed a wide scope of material ranging from qualitative observations to detailed quantitative studies of specific subjects. While certain studies were of limited value, many were pertinent and have been integrated, where applicable, into the analyses presented. A bibliography of the literature reviewed is presented in Appendix B.

2. A review of present conditions and historical trends in land ownership patterns, government facilities and a broad range of interest areas including biology, geology, erosion hazards, recreation, economy, culture, and history was conducted.

3. Field examinations of selected island sites were conducted and numerous interviews with inhabitants, officials in the island region, and the regional agencies whose mission involves resource management and/or planning took place.

Land Ownership and Development Patterns

The islands of Lake Erie are concentrated in the western basin region. Islands occur in both United States and Canadian waters of this region. The United States islands are located in four counties of the State of Ohio (Table 1). Without question, the Ohio islands are more extensively developed than are the Canadian islands of Essex County, Ontario. Of the Canadian islands, only Pelee Island sustains a permanent population. Pelee Island is the largest in the region and is developed as an agricultural, fishing and tourist area. The size, development and physical characteristics of each of the islands in the region are summarized in Table 3. If a dock, causeway or landing strip of any kind is present to allow access to an island, access is noted as yes in Table 4.

The Ohio islands are utilized in slightly differing manners. The existing land uses in Catawba, Danbury and Put-in-Bay Townships are summarized in Table 4. Catawba Township delimits the peninsular portion of Ottawa County often referred to as Catawba Island. Johnson Island, in Sandusky Bay, is part of Danbury Township. The latter township encompasses Ottawa County's Marblehead peninsula. With the exception of Turtle and West Sister Islands in Lucas County and Kelleys

TABLE 3

INVENTORY OF ISLANDS OF WESTERN LAKE ERIE*

Island	County	Shore Length (Statute Miles)	Area Sq. Miles	Area Total Acres	Public Acreage	Private Acreage	Per Cent Developed	Access	Physical Characteristics: Topography	Cover	Shoretype
Ballast	Ottawa	0.7	-	12	0	12	51-75	Yes	100% level	50% developed 50% grass and trees	80% bluff 20% rubble beach
Big Chicken	Essex(Can.)	0.1	-	1	N.A.	N.A.	0	No	Rubble mound	100% barren rubble	100% rubble beach
Catawba	Ottawa									40% developed	100% beach
East Harbor		6.6	1.41	902.4			25-50	Yes	100% level	60% marsh	
West Harbor	Ottawa	5.9	0.64	409.6	1691	N.A.	50-75	Yes	100% level	70% developed 30% marsh	100% beach
Middle Harbor	Ottawa	3.7	0.42	268.8			10-25	Yes	100% level	10% developed 90% marsh	100% beach
East Sister	Essex(Can.)	1.0	0.10	65	N.A.	N.A.	0	No	100% level	100% forest	20% bluff 80% beach
Gibraltar	Ottawa	0.5	-	6	6	0	75-100		100% rolling	30% developed 70% grass and trees	50% bluff 50% beach
Green	Ottawa	0.8	-	17	17	0	0	No	100% level	100% forest	100% bluff
Hen	Essex(Can.)	0.4	-	5.75	N.A.	N.A.	0	Yes	100% rolling	20% developed 80% grass and trees	90% bluff 10% beach
Horseshoe	Ottawa	0.8	-		N.A.	0	0	No	100% level		100% beach
Johnson	Ottawa	3.3	0.45	288	8	280	15-25	Yes	100% level	5% grass 10% developed 75% forest 10% other	90% bluff 10% beach
Keileys	Erie	11.4	4.37	2797	672	2120	25-50	Yes	90% level 10% rolling	20% grass 10% forest 10% marsh 50% other	90% bluff 10% beach
Little Chicken	Essex(Can.)	-	-	<1	N.A.	N.A.	0	No	100% barren	100% water covered during high water year	100% beach
Middle	Essex(Can.)	0.9	0.1	52	0	52	1-10	Yes	100% level	10% grass 90% forest	65% bluff 10% beach
Middle Bass	Ottawa	7.7	1.27	813	0	813	51-75	Yes	100% level	30% grass 20% cultivated 30% forest 20% developed	20% beach 80% bluff
Middle Sister	Essex(Can.)	0.5	-	10	0	10	0	No	100% level	100% forest	90% bluff 10% beach
Mouse	Ottawa	0.5	-	5	0	5	0	No	100% level	100% forest	90% bluff 10% beach
North Bass	Ottawa	5.2	1.10	704	0	704	51-75	Yes	100% level	20% forest 60% cultivated 10% marsh 10% developed	85% bluff 15% beach
North Harbor	Essex(Can.)	0.2	-	3	0	3	25-50	Yes	100% rolling	20% developed 80% grass and trees	90% bluff 10% beach
Pelee	Essex(Can.)			10108	0	10108	51-75	Yes	100% level	grass, forest, cultivated, developed, other, marsh	bluff beach
Rattles	Ottawa	0.05	-	<1	0	<1	0	No	rolling	100% shrub	100% cliff
Rattlesnake	Ottawa	1.6	0.10	60	0	60	25-50	Yes	70% level 30% rolling	40% grass 30% forest 30% developed	95% bluff 5% beach
South Bass	Ottawa	10.7	2.45	1570	70	1500	51-75	Yes	50% level 50% rolling	30% grass 30% cultivated 20% forest 20% developed	90% bluff 10% beach
Squaw	Sandusky	0.2	0.005	3.2	0	82	0	No	100% level	100% shrub	100% beach
Starve	Ottawa	0.2	-	<1	0	<1	0	No	100% level	95% barren 5% trees	100% beach
Sugar	Ottawa	0.9	-	40	0	40	25-50	Yes	100% level	10% grass 70% forest 20% developed	50% bluff 50% beach
Turtle	Lucas	0.1	-	<2	0	<2	51-75	No	100% rolling	60% developed 40% shrub	
West Sister	Lucas	1.3	0.12	80	80	0	0	No	100% level	95% forest	70% bluff 30% rubble beach

* Appendix 12: Shore Use and Erosion, Great Lakes Basin Framework Study. GLBC, 1975 (In part)

TABLE 4

EXISTING AND PROPOSED LAND USES IN ISLAND REGION TOWNSHIPS[1]

	Catawba Township	Danbury Township	Put-in-Bay Township
Area			
Square miles	5.64	17.76	4.44
Acres	3,610	11,366	2,842
Per Cent of Ottawa County	2.22	6.98	1.75
Existing Land Use (Acres)			
Residential	1,238	2,234	546
Agricultural	1,546	3,737	1,386
Manufacturing	15	13	17
Commercial	163	188	191
Governmental	12	50	19
Streets and highways	101	248	103
Non-highway R/W	51	178	55
Recreation and open space	407	2,414	458
Water and wetlands	77	58	67
Extractive (Quarry)	0	2,246	0
Total	3,610	11,366	2,842
Proposed Additional Land Uses-Through 1975 (Acres)			
Residential	360	227	28
Local Roads	63	40	5
Resort Commercial	170	170	0
Local Park	38	24	0
Other governmental	0	2	0
Total	631	499	33

1 Finkbeiner, Pettis and Strout, Ltd. 1971. Vol. 2. Regional development plan. Ottawa County Comprehensive Planning Program.

Island in Erie County, the remaining Ohio islands comprise Ottawa County's Put-in-Bay Township. Green Island, Mouse Island, Starve Island and West Sister Island can be considered undeveloped and lack access.

Property ownership of the Ohio islands has been extensively investigated as part of this study. Mailing addresses for shore zone property land owners, local addresses, land uses and assessed property values for each island are presented in Appendix A. Assessed property value in all the Ohio counties in which islands occur is thirty-five percent of appraised value. The predominant land use is for seasonal residential purposes. This classification (Table 5), reflects the extensive use of the coastal zone for summer cottages. Johnsons Island carries this pattern to extreme with 167 residential parcels located along 3.3 miles of shoreline. Kelleys Island, Middle Bass Island and South Bass Island have areas divided into 179, 169, and 243 residential parcels, respectively. Many residential parcels on these four islands are, as yet, undeveloped. The latter observation is evident in the number of these parcels with a low assessed value, Table 6.

Agricultural and commercial categories describe the remaining land uses for island properties. The number of agricultural and commercial parcels is very small in comparison to the number of residential parcels. Parcels of land with high assessed values are either commercial holdings such as a motel or cottage complex or large agricultural holdings for vineyards. The number and type of parcel are summarized in Table 5. The range of assessed value for these parcels is summarized in Table 6.

The importance of the islands to the people of the State of Ohio is evident in large numbers of property owners who reside in the state's metropolitan centers, principally the greater Cleveland area. The number of island property owners using islands as their principal mailing address, i.e. local residents, is small in relation to the total number of owners. The distribution of property owners in Ohio's metropolitan centers is summarized in Table 5. The number of property owners listing out-of-state addresses is quite small.

Transportation

Ferry Service. The island area is provided with regularly scheduled ferry service by three boat lines. Miller Boat Lines and Parker Boat

TABLE 5
SHORELINE LAND CLASSIFICATION AND MAILING ADDRESSES
OF SHORE ZONE PROPERTY OWNERS

Island	Total Number of Parcels	Agricultural Parcels	Commercial Parcels	Residential Parcels	Local Island Address	Cleveland Address	Greater Cleveland/ Lorain Area Address	Greater Columbus Address	Other Ohio Resident Address	Ottawa Co. Mainland Address	Sandusky Area	Greater Toledo Area	Out-of-State Address
Ballast	5	–	–	5	–	2	–	1	–	–	–	–	1
Gibraltar	1	–	–	–	–	–	–	–	–	–	–	–	–
Green	1	–	–	–	–	–	–	–	–	–	–	–	–
Johnson	169	1	–	167	–	45	73	2	15	8	9	3	6
Kelleys	214	18	16	179	33	17	45	3	30	3	21	2	23
Middle Bass	182	8	5	169	10	17	41	10	41	6	8	15	8
Mouse	1	–	–	1	–	–	1	–	–	–	–	–	–
North Bass	20	8	3	12	1	5	–	–	3	4	–	1	1
Rattlesnake	1	–	1	–	–	–	–	–	–	–	1	–	–
South Bass	271	11	14	243	53	27	49	15	42	6	7	15	20
Starve	1	–	–	1	–	–	–	–	–	–	1	–	–
Sugar	2	–	–	1	–	–	–	1	–	–	–	–	–
West Sister	1	–	–	–	–	–	–	–	–	–	–	–	–
Turtle	1	–	–	1	–	–	–	–	–	–	–	1	–

TABLE 6

ASSESSED VALUE OF PRIVATELY OWNED SHOREZONE PROPERTY

Assessed Value / Island	0-2000		2001-4000		4000-6000		6001-8000		8001-10,000		10,000-12,000		12,000 14,000		14,001 16,000		16,001-20,000		20,000 and UP	
	N	%[1]	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Ballast	-	-	2	40	1	20	-	-	2	40	-	-	-	-	-	-	-	-	-	-
Johnson	62	36	38	22	22	13	18	11	11	7	11	7	6	4	-	-	-	-	-	-
Kelleys	100	44	25	11	22	10	30	13	18	8	12	5	8	4	3	1	2	1	6	3
Middle Bass	68	38	6	3	28	15	32	18	21	12	12	7	3	2	1	1	4	2	4	2
Mouse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-
North Bass	6	30	5	25	3	15	2	10	1	5	-	-	-	-	-	-	1	5	2	10
Rattlesnake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100
South Bass	37	14	24	9	37	14	41	16	43	17	30	12	18	7	4	2	10	4	14	5
Starve	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sugar	-	-	-	-	1	50	-	-	-	-	-	-	-	-	-	-	-	-	1	50
Turtle	-		1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Rounded to nearest whole number

Lines serve South Bass Island and Middle Bass Island. Miller Boat Line is the principal carrier for South Bass Island; Parker Boat Line is the principal carrier for Middle Bass Island. Neuman Boat Lines is the only carrier for Kelleys Island. The service period for all the boat lines extends from the first week in April to the third week in November. The characteristics of the vessels providing scheduled ferry service is summarized in Table 7. Service is discontinued during the intervening winter season. Although the lake in this area seldom becomes ice covered before late December and is usually ice free in late February ferry service is limited for a longer period by cold water temperatures. Lake water temperatures of 36° F or below result in dangerous spray ice formation on the superstructure. The weight of the spray ice formations results in an increased vulnerability to floundering in rough water.

This ferry service provides the only means of delivering bulk materials and other freight to the islands. Parker Boat Lines provides bulk deliveries to the islands in the Bass Island group not provided with regularly scheduled service; reservations are required. Neuman Boat Line is contracted by the Meiers Wine Co., to provide North Bass Island with near daily service during the month long grape harvest. The grape harvest extends from late September to late October. The North Bass harvest is transported to Sandusky and subsequently by rail to Silverton, Ohio for pressing and wine making.

The island ferries are busiest in the summer months of June, July, and August. All operate extended schedules during this period. The period of least use in every instance occurs in the months of April and November. Schedules are abbreviated during these months; even so, the ferry lines often operate at a deficit during the period. Summer users are largely day visitors to the island region and cottage owners. Very early spring users and very late fall users are largely local residents. Obviously, local residents alone do not provide sufficient volume to allow a profit-making enterprise.

Ferry service from Sandusky, Ohio to Pelee Island and the Ontario mainland is provided by The Pelee Island, Leamington and Kingsville Boat Line. The M.V. Pelee Islander operates daily between Leamington or Kingsville, stopping at the Pelee Island, West Dock on each passage. The schedules and rate structure for each of the boat-lines is listed in Appendix A.

The Crew's Nest of Put-in-Bay offers water taxi service from South Bass Island to the Ohio mainland as well as the other islands. This service is available by reservation. Several marinas offer a similar service during the summer season.

TABLE 7

SUMMARY OF SCHEDULED VESSELS SERVING THE ISLAND REGION

Boat Line	Vessel	Size	Power	Crew	Rated Passenger Capacity	Rated Automobile Capacity	Principal Points of Service
Miller	William Miller	64'10"	385HP Cat. Diesel single screw	3	250	10	Catawba Isl.- South Bass Isl.
	Put-in-Bay	64'10"	220HP GM Diesel twin screw	3	150	10	Catawba Isl.- South Bass Isl.
	West Shore	64'10"	400HP GM Diesel single screw	3	250	10	Catawba Isl.- South Bass Isl.
Neuman	Challenger	70'	220HP GM Diesel single screw	3	250	7	Sandusky- Kelleys Isl.
	Commuter	65'	220HP GM Diesel single screw	2	150	9	Marblehead- Kelleys Isl.
	Corsair	65'	220HP GM Diesel single screw	2	150	9	Reserve vessel
	Kelley Islander	100'	680HP GM Diesel twin screw	3	150	15	Marblehead- Kellys Isl.
Parker	Erie Isle	64'10"	671HP GM Diesel twin screw	3	180	6	Port Clinton- Middle Bass/ South Bass Isl.
	Yankee Clipper	64'10"	Cat. Diesel single screw	3	150	9	Port Clinton- Middle Bass/ South Bass Isl.

The exact history of ferry service to the Bass Islands is indistinct in the minds of those familiar with it. Miller Boat Lines originated in the 1930's with a small tug pulling a barge from Catawba Island to South Bass Island. Miller Boat Lines ordered the construction of its first actual ferry in the 1940's and this vessel, the South Shore was placed in service in 1945. Miller Boat Line sold the South Shore in 1975. Parker Boat Line represents the effort of Alfred Parker to combine the Parker Boat Line and the Erie Isle Ferry Company. Local businessmen, principally George Lonz, of Middle Bass Island, established the Erie Isle Ferry Company in the 1930's. The Erie Isle Ferry Co. initially operated a wooden vessel named the Erie Isle. This vessel was subsequently replaced by the present steel-hulled vessel of the same name. Alfred Parker operated the M.V. Yankee Clipper along the same route as the Erie Isle Ferry Co. In recent years Capt. Parker obtained controlling interest in The Erie Isle Ferry Co. and subsequently dissolved that firm. The history of the Neuman Boat Lines was prepared by Ferris (1973). This line spans 70 years of service to the islands and included the operation of eleven vessels.

Airline Service. The island area is provided with regularly scheduled flight service by two air carriers. Sky Tours, Inc., better known as Island Airlines, serves North, Middle and South Bass Islands, and Kelleys Island on a regular basis. Rattlesnake Island is served by reservation only. Griffing Flying Service, Inc., serves Kelleys Island and Pelee Island. Aircraft used to provide regular scheduled service is listed in Table 8. In addition to scheduled service, both carriers are prepared to provide charter service at non-scheduled hours.

During the winter months, aircraft provide the only regular transportation to and from the islands. During this period, aircraft carry all passengers, supplies and freight to and from the islands. Mail service throughout the year is provided only by aircraft.

Aviation buffs from throughout the world, as well as many Ohio residents, visit South Bass Island in order to fly aboard the 1927 Ford Trimotor, the famous "Tin Goose." Island Airlines officials instituted a new policy concerning this aircraft in 1977. This truly unique aircraft is currently being refurbished and will carry only passengers during the tourist season. It will no longer be used to carry freight nor will it be flown in winds exceeding 15 knots. This policy is designed to preserve the working life of an aged, irreplaceable aircraft.

TABLE 8

AIRCRAFT PROVIDING REGULARLY SCHEDULED SERVICE
TO THE LAKE ERIE ISLANDS IN OHIO

Type of Aircraft	Number	Passenger Capacity	Operator	Points of Service
Cessna Skyhawk 172	3	3	Sky Tours, Inc.	Port Clinton-All Ohio Islands
de Havilland Otter DHC/3	1	10	Sky Tours, Inc.	Port Clinton-All Ohio Islands
de Havilland Beaver DHC/2	1	7	Sky Tours, Inc.	Port Clinton-All Ohio Islands
Ford Tri-motor	1	15	Sky Tours, Inc.	Port Clinton-All Ohio Islands
Piper Commanche	1	3	Sky Tours, Inc.	Port Clinton-All Ohio Islands
Piper Aztec	2	6	Griffing Flying Service, Inc.	Sandusky - Kelleys Isl., Pelee Isl.
Piper Cherokee	1	6	Griffing Flying Service, Inc.	Sandusky - Kelleys Isl., Pelee Isl.
Piper Cherokee	5	4	Griffing Flying Service, Inc.	Sandusky - Kelleys Isl., Pelee Isl.
Piper Navajo	1	6	Griffing Flying Service, Inc.	Sandusky - Kelleys Isl., Pelee Isl.
Piper Seneca	1	6	Griffing Flying Service, Inc.	Sandusky - Kelleys Isl., Pelee Isl.

TABLE 8 (Continued)

AIRPORT FACILITIES IN THE LAKE ERIE ISLAND REGION

AIRPORT NAME	LOCATION	Runways				Owner-ship	Hangers	Airplane Service	Pilot Center
		Length	Dir.	Surf.	Lt.				
Griffing-Sandusky	Sandusky	3567 2600	EW NS	Paved Paved	Yes Yes	Pvt	Yes	Yes	Yes
Huron	Huron	1800 2800	EW NS	Sod Gravel	Yes No	Pvt	Yes	Yes	Yes
Kelleys Island Municipal	Kelleys Is.	2217 2265	EW NS	Paved Paved	Yes Yes	Pub	No	No	Yes
Lonz	Middle Bass Is.	1750	EW	Gravel	No	Pvt	No	No	No
Middle Bass	Middle Bass Is.	2700	EW	Sod	No	Pvt	No	No	No
North Bass	North Bass Is.	1900 1900	EW NS	Sod Sod	No No	Pvt	No	No	No
Port Clinton (Carl R. Keller Field)	Port Clinton	5000 3980	EW NS	Paved Paved	Yes Yes	Pub	Yes	Yes	Yes
Put-in-Bay	South Bass Is.	3100 1600 1550	NE/SW NS EW	Paved Sod Sod	Yes No No	Pvt	Yes	No	Yes
Rattlesnake	Rattlesnake Is.	1750 1500	EW NS	Sod Sod	No No	Pvt	No	No	No
Toledo Seaport (Keller's)	Maumee Bay	4500	EW	Water	No	Pub	Dock	Yes	Yes

There are no large passenger airports in the island region. The general aviation airports in Erie and Ottawa Counties are categorized as commercial. Erie and Ottawa Counties have agreed to mutually develop the Port Clinton Airport in Ottawa County (Carl R. Keller Field). The largest commercial airport in Erie County is Griffing-Sandusky, a private facility in the city of Sandusky. The Port Clinton airport serves as the point of origin for Island Airlines; the Sandusky airport serves as the point of origin for Griffing Flying Service. The Kelleys Island Municipal Airport is a small commercial facility owned by the Village of Kelleys Island. Put-in-Bay Airport is owned and operated by Travelair Taxi of which Sky Tours, Inc. is a wholly owned subsidiary. Characteristics of the airports in the region are summarized in Table 8.

Commercial airports serve local aviation primarily with inter-island and inter-city itinerate flying performed in single-engine aircraft of less than four places. Transient aircraft average 18 flights on weekdays and 75 on weekends at Put-in-Bay during the summer months. These transient flights originate in Kentucky, Michigan, Pennsylvania and Ohio. Approximately fifty percent of these flights originate in Ohio.

GEOLOGY OF THE LAKE ERIE ISLAND REGION

Hydrography

The bed of Lake Erie lying west of a line from Cedar Point (Ohio) at the mouth of Sandusky Bay to Point Pelee (Ontario) constitutes a distinct physiographic unit known as the western basin. This basin is separated from the deeper central part of the lake by a belt of resistant bedrock islands and reefs. The western basin comprises 13% (1,265 sq. miles) of the total lake area but due to its shallowness it only contains 5% (5.8 cu. miles) of the total lake volume. The mean depth of the basin is only 24 feet and the bottom is quite flat except for the sharply rising islands and reefs, which are cuesta-shaped erosional remnants of Paleozoic limestones and dolomites. The deepest sounding in the basin, 62 feet, was made in a small depression south of Starve Island (Herdendorf, 1970). Another depression north of Kelleys Island is 54 feet deep; elsewhere in the basin depths do not exceed 45 feet.

The islands and reefs are arranged in three roughly north-south belts, with the exception of Turtle Island in Maumee Bay which is isolated from the western basin islands. The most westerly belt lies north of Locust Point and includes approximately 12 reefs and West Sister Island. The middle belt extends from Catawba Island through the Bass Islands and consists of at least 14 reefs and 10 islands. The easterly belt encompasses Johnson Island, Marblehead Peninsula, Kelleys Island, and about seven reefs and shoals. The areas and shore lengths of the major islands are given in Table 9 and the areas and least depths of the major reefs are listed in Table 10. This arrangement and the cuesta[1] shape of the islands are controlled by the structure and relative resistance of the underlying bedrock.

The shoreline of Catawba Island from Rock Ledge to West Harbor is six miles long and consists of an alternation of rocky headlands and glacial till bluffs. The dolomite headlands rise to 70 feet above lake level, whereas the glacial till is much less resistant to erosion and has been cut back into coves and indentations along the coast. Pebble and cobble beaches have formed locally in the coves. The four miles of shore from West Harbor to Lakeside is low and bordered by sand beaches. The beaches lie on marsh deposits which formed in the shallow bay between Catawba Island and Marble-

1 See page 27 for a discussion of cuesta.

TABLE 9

ISLANDS WITHIN STUDY AREA

Island	Area		Shore Length (miles)
	Square Miles	Acres	
Kelleys	4.37	2,797	11.4
South Bass	2.45	1,568	10.7
Middle Bass	1.27	813	7.7
North Bass	1.10	704	5.2
West Sister	0.12	77	1.3
Rattlesnake	0.10	65	1.6
Sugar	0.05	29	0.9
Green	0.03	18	0.8
Ballast	0.02	12	0.7
Mouse	0.01	7	0.5
Gibraltar	0.01	6	0.5
Starve	0.00	1	0.2
Totals	9.53	6,097	41.5

TABLE 10

REEFS WITHIN STUDY AREA

Reef	Area		Least Depth (feet)
	Square Miles	Acres	
West Reef	2.05	1,312	4
Niagara Reef	0.96	614	3
Gull Island Shoal	0.79	504	+1
Kelleys Island Shoal	0.74	470	2
Scott Point Shoal	0.57	362	10
Middle Harbor Reef	0.54	346	1
Toussaint Reef	0.49	314	3
Locust Point Reef	0.36	230	5
Round Reef	0.34	218	7
Mouse Island Reef	0.33	211	9
Crib Reef	0.33	210	2
Little Pickerel Reef	0.28	179	15
Starve Island Reef	0.26	166	7
Cone Reef	0.26	165	10
Lakeside Reef	0.02	16	12
Totals	8.31	5,317	

head Peninsula. The underlying material is glacial till and lacustrine clay. An extensive sand deposit has accumulated in the East Harbor area and low sand dunes have formed behind the beach.

The Marblehead Peninsula shore arcs for four miles from Lakeside to the base of Bay Point and is lined with limestone and dolomite bluffs, generally less than 20 feet above lake level. Sections of the shore are composed of thin-bedded rock which yields to wave attack; elsewhere the rock is massively bedded and more resistant to erosion. Glacial till commonly caps the bluffs. The narrow pebble beaches which line the shore at the base of the bluffs have been largely derived from the bedrock. Bay Point extends southward from Marblehead Peninsula for two miles into Sandusky Bay. This point is a compound spit that is growing from sand contributed by littoral currents moving along Cedar Point and around the end of the Sandusky harbor jetty.

The shores of all of the major islands are rockbound, chiefly rugged in character, with bluffs along the major portions of the island perimeters. The highest elevations are normally adjacent to the west shores, except West Sister Island where the bluffs are highest along the east shore. The upland area adjacent to the west shore of South Bass Island (Victory Woods) reaches a height of 70 feet above lake level, the highest elevation in the islands. Small sand, cobble, or boulder beaches are situated at indentations in the shoreline. The most extensive sand beach lies along the north bay of Kelleys Island.

Johnson Island, lying in Sandusky Bay adjacent to Bay Point, is composed of low limestone and glacial till shores. The shore is bordered by discontinuous cobble beaches. Turtle Island, in Maumee Bay, is the only natural island in western Lake Erie not composed of bedrock. Turtle Island is an elevated terminous of a sand spit that was formed by littoral currents. Erosion of this sandy material has reduced the size of the island from seven acres to its present 1.5 acres in the past fifty years. The island is now protected by a seawall and has no beaches.

The reefs consist of submarine bedrock exposures and associated rock rubble and gravel. The topography of the reef tops varies from rugged surfaces caused by bedrock pinnacles and large boulders to smooth slabs of nearly horizontally bedded rock. In places the exposed bedrock has the appearance of low stairs with the "steps" dipping

slightly to the east from the fringe of the reefs to its crest. All of the bedrock formations that form the reefs are carbonate rocks which contain abundant solution cavities. Most of the reefs are conical in shape and elongated, as are many of the islands, in a northeast-southwest direction. Two factors appear to have influenced this elongation: (1) vertical joint systems in the bedrock which are oriented parallel to the elongation and (2) the elongation is in general agreement with the major trends of glacial ice movements as deduced from grooves found on the islands.

Bedrock Stratigraphy

The bedrock in the island region of western Lake Erie is sedimentary in origin and was deposited as lime muds in shallow, warm Silurian and Devonian seas, which covered the region from 410 to 375 million years ago. The warm, clear conditions of the sea can be inferred from the abundant fossil corals and other invertebrates found in the rocks on Kelleys and Johnson Islands. The abandoned limestone quarries in Kelleys Island State Park are excellent sites for fossil collecting and have yielded over 70 species of marine organisms (Stauffer, 1909). A generalized section of the rocks which occur in the island region is given in Table 11 and the outcrop pattern of bedrock formation exposed in western Lake Erie are depicted on Figures 1 and 2 .

The dominant structural feature of the bedrock underlying western Lake Erie is the Cincinnati Arch. The nearly north-south axis of this arch passes through the island region and then plunges gently to the north. A study of the structure of Precambrian or basement rock of Ohio by Owens (1967) indicated that the crest of the arch lies a few miles east of West Sister Island. As a consequence of the alignment of the arch, the overlying Paleozoic bedrock dips to the east at approximately 20-40 feet per mile in the Bass-Kelleys Islands area. For this reason, the oldest rocks are exposed on West Sister Island and successively younger formations crop out to the east along the flank of the arch.

The bedrock exposed on West Sister Island and on the reefs in the vicinity of Locust Point as far east as Niagara Reef is the lower portion of the Tymochtee Dolomite. This formation is highly variable in its resistance to weathering, a factor that may explain the

TABLE 11

GENERALIZED SECTION OF ROCKS IN THE ISLAND REGION OF WESTERN LAKE ERIE

SYSTEM	GROUP	FORMATION	THICKNESS (in feet)	DESCRIPTION
DEVONIAN		Delaware	70	Limestone, dark- to bluish-gray, thin-bedded, calcareous shale partings; contains nodular chert; occurs in vicinity of Sandusky.
		Columbus	60	Limestone, light-gray to buff, moderately thin- to massive-bedded, very fossiliferous; locally changes to dolomite, exposed on Kelleys Island, Marblehead, and at Sandusky.
	Detroit River Group	Lucas	30-75	Dolomite, gray to drab, thin- to massive-bedded, relatively non-resistant; carbonaceous parting between layers; occurs in western part of Kelleys Island, on Marblehead, and southwest of Sandusky.
		Amherstburg	60-80	Dolomite, drab to brown, massive-bedded, relatively non-resistant; exposed on shore near Lakeside.

TABLE 11
(continued)

SYSTEM	GROUP	FORMATION	THICKNESS (in feet)	DESCRIPTION
SILURIAN	Bass Islands Group	Raisin River	40-60	Dolomite, blue-gray to drab, thin-bedded to shaly, argillaceous; occurs on Bass Islands and on Marblehead peninsula between Lakeside and Catawba Island.
		Put-in-Bay	35	Dolomite, gray to drab, medium-bedded, brecciated, rough-textured, crystalline; weathers with irregular knobby surface; occurs on South Bass Island, Green Island, Catawba Island.
	Salina Group	Tymochtee	125-175	Dolomite, dark-bulish-gray to brown, thin-bedded to shaly; calcareous shale partings in upper beds; contains gypsum and anhydrite; occurs on South Bass Island, Catawba Island and West Sister Island.
		Greenfield	400	Dolomite, light-drab to yellowish-brown, thin- to massive-bedded; generally dense and hard but some layers granular or vesicular; exposed at Rocky Ridge in Ottawa County.
	Niagara Group	Lockport (Guelph)	50-80	Dolomite, white, light-gray, or bluish-gray, massive-bedded, crystalline; open and porous in texture; occurs in southwest Ottawa County.

FIGURE 1
LEGEND FOR GEOLOGIC MAP OF WESTERN LAKE ERIE

ONTARIO

System	Formation	Symbol	Lithology	Thickness in feet
Devonian	Hamilton	Dha	Shale	250
	Delaware	Dd	Limestone	100
	Columbus	Dc	Limestone	40
	Detroit River	Ddr	Dolomite	250
Silurian	River Raisin	Srr	Dolomite	40

MICHIGAN

Mississippian	Coldwater	Mc	Shale	500
	Berea	Mbe	Sandstone	0-120
Devonian	Antrim	Dat	Shale	100-450
	Ten Mile Creek	Dt	Dolomite	40
	Silica		Shale	45
	Dundee	Ddd	Limestone	50-350
	Anderdon	Ddr	Limestone	25
	Lucas		Dolomite	200
	Amherstburg		Dolomite	20-50
	Sylvania	Ds	Sandstone	90-250
Silurian	River Raisin	Srr	Dolomite	200
	Put-in-Bay	Sp	Dolomite	50-100
	Tymochtee	St	Dolomite	90
	Greenfield	Sg	Dolomite	125

OHIO

Mississippian	Berea	Mbe	Sandstone	10-50
	Bedford	Mbd	Shale	0-150
Devonian	Cleveland	Dcl	Shale	30-70
	Huron	Dh	Shale	600
	Prout	Dp	Limestone	15
	Plum Brook	Dpb	Shale	35
	Delaware	Dd	Limestone	70
	Columbus	Dc	Limestone	60
	Lucas	Dl	Dolomite	30-75
	Amherstburg	Dah	Dolomite	60-80
Silurian	River Raisin	Srr	Dolomite	40-60
	Put-in-Bay	Sp	Dolomite	35-60
	Tymochtee	St	Dolomite	150
	Greenfield	Sg	Dolomite	500
	Lockport	Sl	Dolomite	50-80

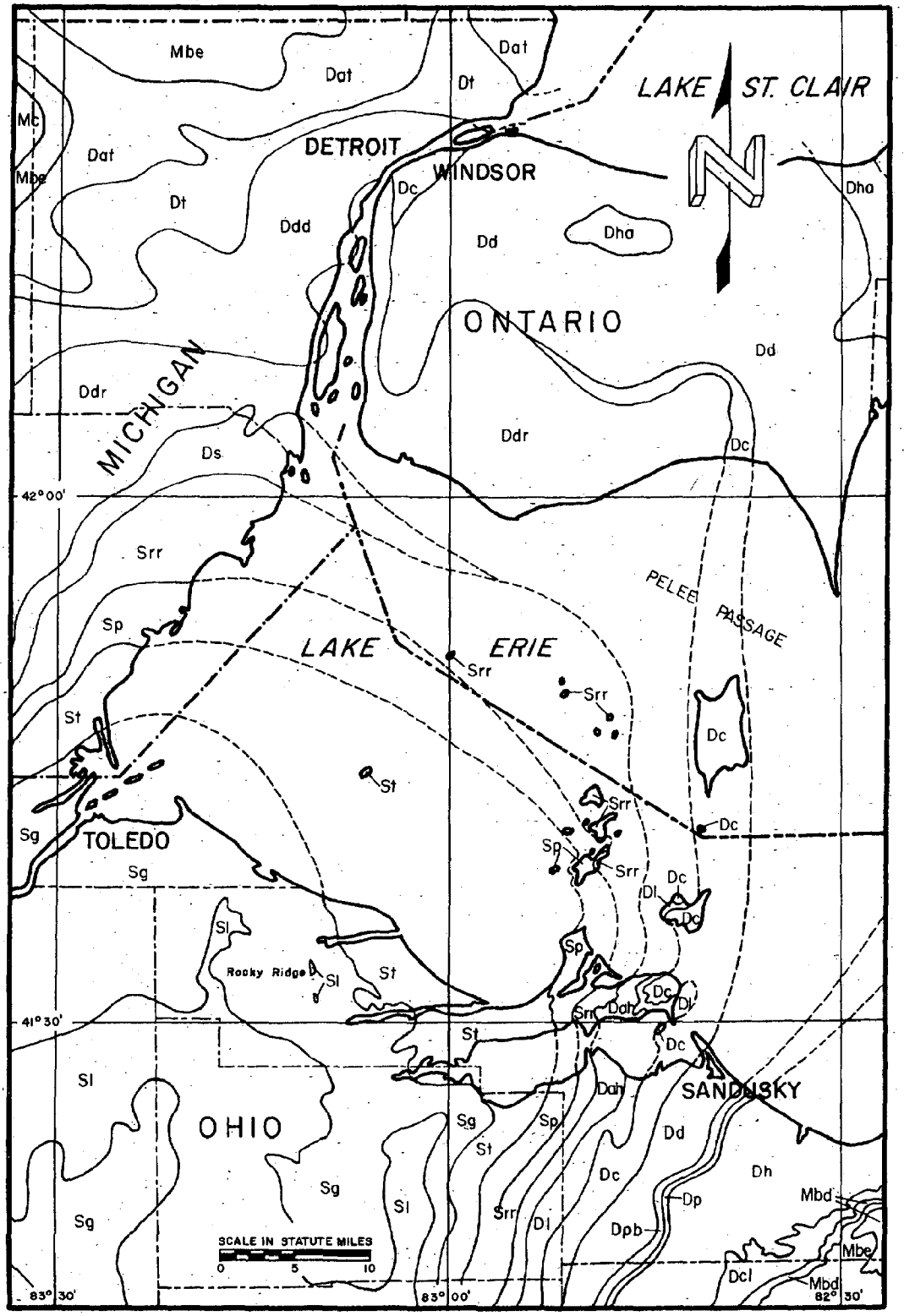
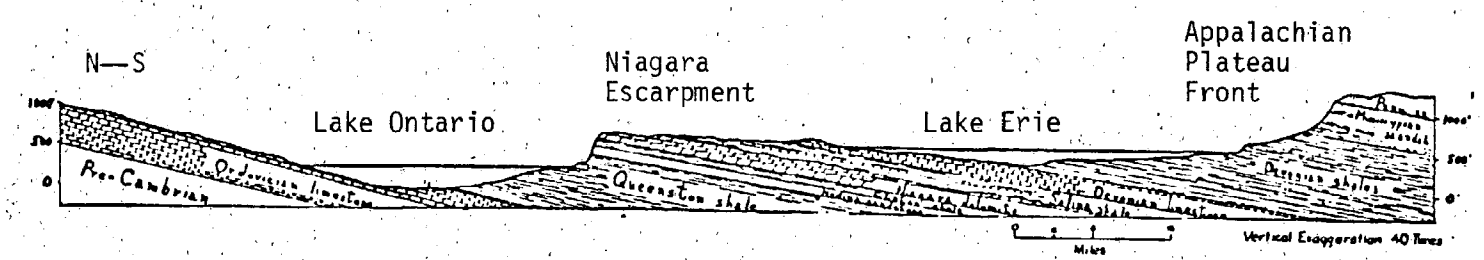
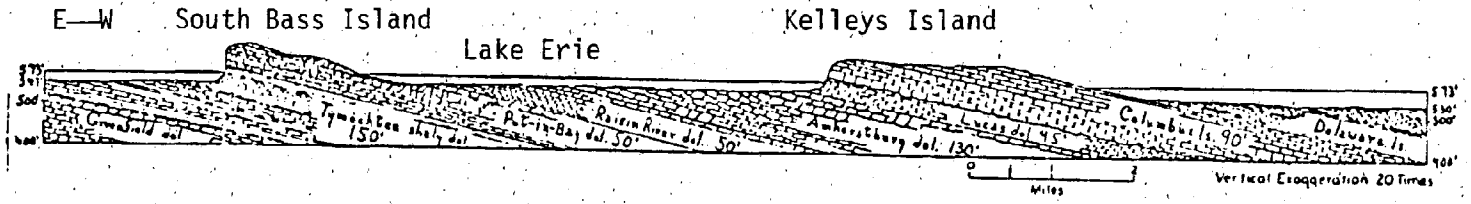


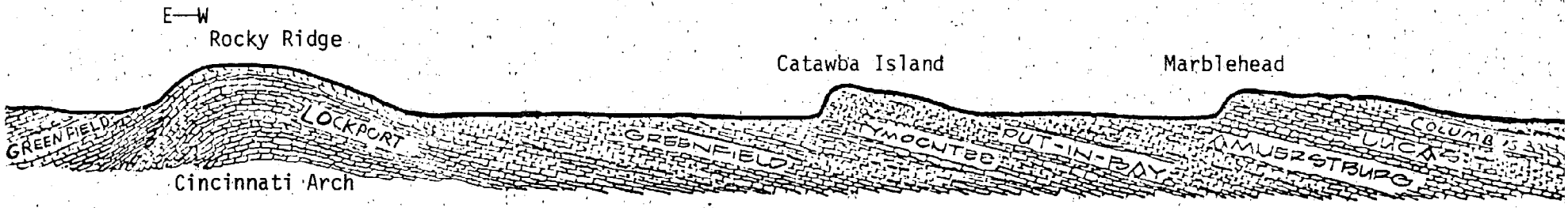
FIGURE 1. GEOLOGIC MAP OF WESTERN LAKE ERIE.



North-south section across the Ontario and Erie Basins and the adjoining uplands showing the relations of the basins and uplands to the lithology of the rock units.



East-west section through South Bass and Kelleys Islands showing the cuesta form of the islands, the rock units, and the rock structure.



East-west cross section of Ottawa County showing the rock units and rock structure underlying Catawba Island and Marblehead.

FIGURE 2. GEOLOGIC CROSS-SECTIONS OF THE LAKE ERIE ISLAND REGION (Carman, 1946 and Herdendorf, 1970).

lack of bedrock reefs between Niagara Reef and the Bass Islands.

The middle and eastern belts of bedrock islands (Catawba-Bass and Johnson-Kelleys) are characterized by high elevations and cliffs at their western shorelines; elevations generally decrease eastward resulting in shelving rock along the eastern shorelines. The resulting topographic form is that of a cuesta or asymmetrical ridge where the gentle slope agrees with the dips of resistant beds and the steeper slope is an eroding cliff maintained partly by undercutting of less resistant rocks. Because West Sister Island lies on the west flank of the Cincinnati Arch the dip of the strata is also to the west. This has resulted in the development of a cuesta with its steep cliff on the east side of the island, the opposite of those formed on the more easterly islands.

Catawba and the Bass Islands are underlain by a band of resistant dolomites of the Bass Island Group. The Put-in-Bay Dolomite of this group is responsible for most of the rugged features of the shoreline. The Tymochtee Formation, which underlies the Put-in-Bay Dolomite at the base of the cliffs, is more readily eroded by waves and results in the undermining of the rock above, which fall away in large blocks, forming nearly vertical walls (Carman, 1946).

The resistant lower beds of the Columbus Limestone are responsible for the easterly chain of bedrock highs, including Johnson and Kelleys Islands. Between South Bass Island and Kelleys Island three formations crop out: Raisin River, Amherstburg, and Lucas Dolomites. All three formations are less resistant than the Put-in-Bay Dolomite and the Columbus Limestone which explains the depression between the islands.

Glacial and Lacustrine Sediments

The unconsolidated sediments within the island region originated from glacial and lacustrine deposition. During the Pleistocene Epoch the islands were covered by at least two continental ice sheets and later by a series of glacial lakes resulting in the deposition of glacial till followed by lake sediments. The surface over which the glaciers advanced was a rugged stream-cut terrain with the present islands standing as hill tops as high as 200 feet above preglacial streams (Herdendorf, 1970). The preglacial drainage system in the islands region appears to have had a trellis pattern. This pattern normally develops in regions with dipping strata of alternating resis-

tant and non-resistant beds. Glaciation moderately scoured this surface during ice advance and buried the preglacial topography under a blanket of till-clay as the glaciers retreated.

As the ice sheets paused in their retreat, ridges or moraines of glacial till were built up at their margins, damming the natural drainage and forming large glacial lakes. Lake Erie is the remnant of such a lake, which at its highest stage (230 feet above present lake level) extended as far southwest as Fort Wayne, Indiana. As the ice retreated, other outlets were uncovered and new lake stages were formed at successively lower levels. When the last glacier retreated from the Niagara sill near Buffalo, New York, a new and final drainage outlet was made available. At that time however, the Buffalo area was as much as 100 feet lower than at present because of the depression it had experienced under the weight of glacial ice. This new outlet resulted in the draining of the western basin and formation of relatively shallow lakes in the central and eastern basins. The outlet gradually rebounded to its present elevation and Lake Erie correspondingly rose from the low stage to its modern level.

During low lake stage (11,000 to 4,000 years ago) much of the lake bottom in the western basin was exposed to subaerial erosion, which greatly altered and reshaped the till and lake sediment surface. In the interval since the drainage of the large glacial lakes, waves and currents of modern Lake Erie have cut into the lake deposits, locally excavating the surficial glacial deposits and exposing the least deeply buried bedrock. The exposed bedrock now forms the islands and reefs.

Maumee Bay and Turtle Island

Maumee Bay is a broad, shallow shelf sloping gently downward toward the northeast. The maximum depth is 10 feet below Low Water Datum (LWD) and the average depth is 5 feet (Benson, 1975). Relief of the bay floor is low except for areas surrounding the navigation channel, which bisects the bay in a northeast-southwest direction. The navigation channel is 500 feet wide and maintained to a depth of 28 feet below LWD. This channel passes 7000 feet to the SE of Turtle Island (Figure 3).

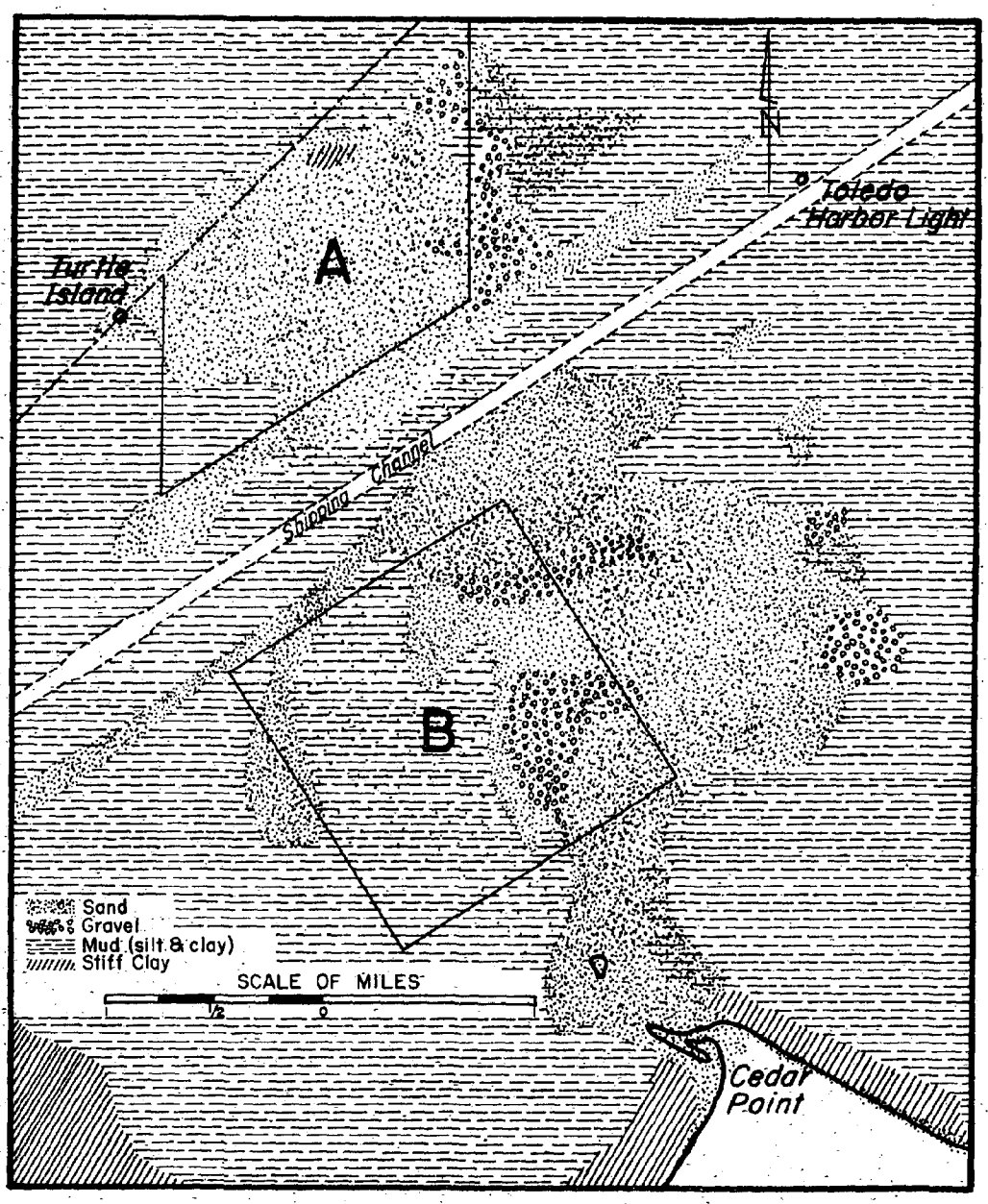


FIGURE 3. BOTTOM SURFACE SEDIMENTS IN MAUMEE BAY DREDGING AREAS (Hartley, 1960)

Geologically, the Turtle Island area consists of a relatively thick layer of sand laying on top of a lacustrine clay layer, up to 30 feet thick. The lacustrine clay was laid down by the glacial lakes which once covered a large part of northwestern Ohio and southeastern Michigan. The lake clay is in turn underlain by sandy glacial till approximately 80 feet thick with a bedrock of Silurian dolomite below (Herdendorf and Cooper, 1975). Figure 4 shows a cross-section of the geologic material forming Turtle Island.

Turtle Island is the terminal end of a sand spit that has formed to the northwest from Cedar Point. Figure 5 shows this sand deposit. The Turtle Island-Cedar Point spit was built by nearshore currents moving northwest between Locust Point and Cedar Point. These nearshore or littoral currents are formed by storm waves approaching from the northeast. The currents pick up sand and gravel, which over time have built up Turtle Island and the sand spit. It should be noted that the navigation channel which passes through the spit has cut off Turtle Island from any replenishment, because it is severed from the littoral current system (Herdendorf and Cooper, 1975). Turtle Island lies adjacent to a commercial deposit of sand and gravel which is dredged to obtain aggregate for the concrete industry.

The primary driving forces that produce current in the Maumee River estuary are wind tides, seiches and river discharge. The estuary and harbor area of Maumee Bay are not greatly affected by longshore currents because of the sheltering effect of man-made fills (Miller, 1968). The outer parts of the bay, in the vicinity of Cedar Point spit and North Cape, are more strongly effected by longshore currents. Wind tides are a direct result of wind stress which pushes water toward the leeward shore, increasing the water level at that shore while it is depressed on the windward shore. As the wind force diminishes, the stress cannot maintain the gradient, resulting in a free oscillation of the lake surface or seiche. The period for a longitudinal seiche (NE-SW) on Lake Erie is approximately 14 hours (Verber, 1960). Wind-produced fluctuation occurring in conjunction with prevailing low or high water have resulted in water levels ranging from 7.5 feet below (U.S. Army, Corps of Engineers, 1945) to 7.4 above (Carter, 1973) LWD.

The Maumee Bay shore and Turtle Island are exposed to storm waves mainly from the east to northeast to north. The maximum fetch distance for the Maumee Bay shoreline is approximately 50 miles which restricts the development of large waves. The shallow nature of the bay causes "deep water" open lake waves to break, reform, and break again several times before they reach the shore, thus dissipating much of their energy (Benson, 1975). The maximum annual "deep water" wave height which could be developed in the western basin of Lake

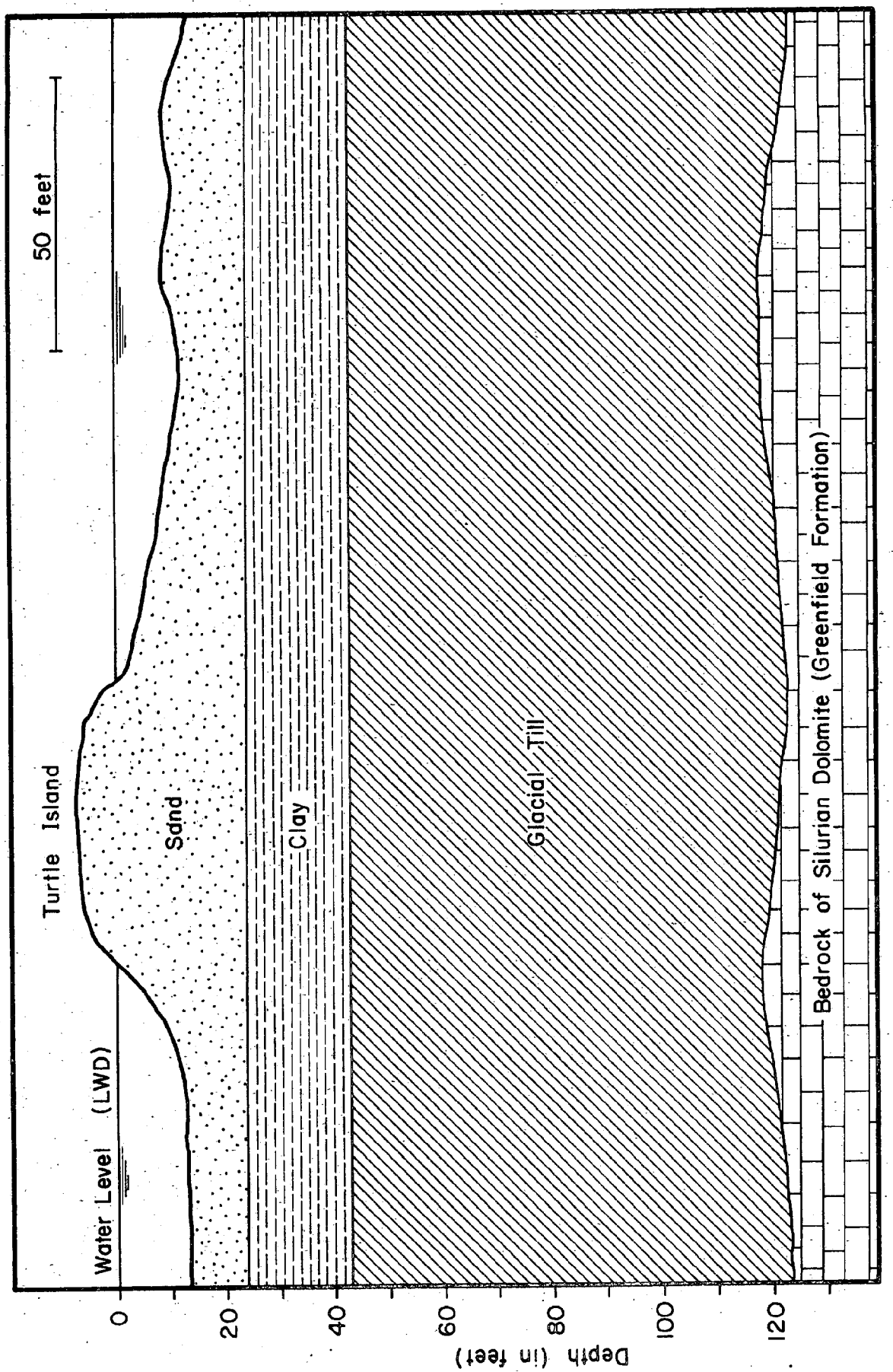
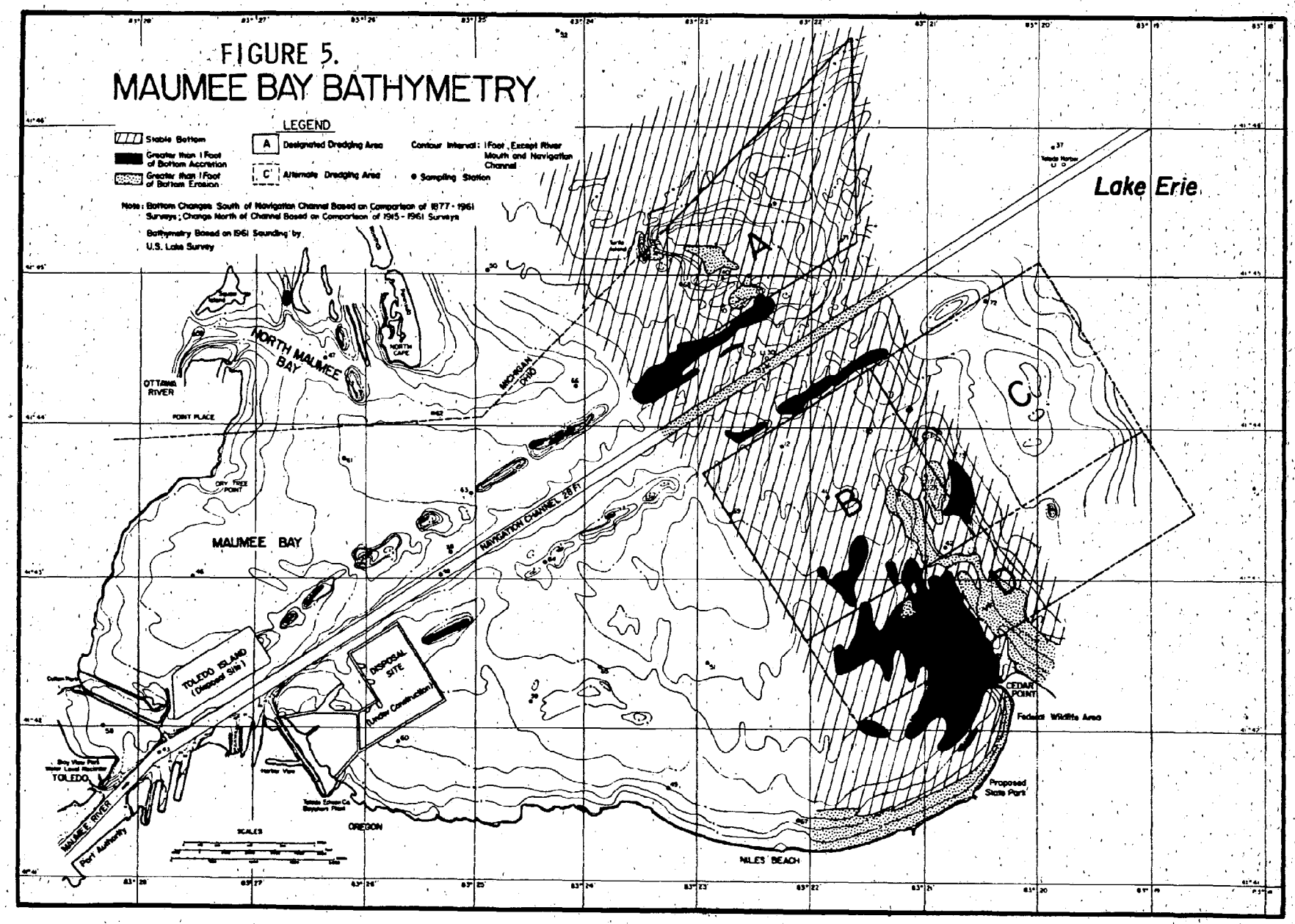


FIGURE 4. GEOLOGIC CROSS SECTION IN THE VICINITY OF TURTLE ISLAND.

FIGURE 5.
MAUMEE BAY BATHYMETRY



Erie has been calculated by the U.S. Army, Corps of Engineers (1953) to be approximately 8.1 feet at Monroe, Michigan during the ice free period of the year. The depth of water at which a wave breaks is approximately 1.3 times the wave height (U.S. Army, Corps of Engineers, 1961). No detailed analysis of wave characteristics is available for Maumee Bay but Benson (1975) stated the generalization that wave heights are lower in the bay than for the open lake due to: (1) predominately offshore winds which do not generate large near-shore waves in the bay, (2) fetch distances are low when compared to other portions of the Lake Erie shoreline and (3) shallowness of the bay which precludes the formation or translation of large waves. In particular he concluded that the spoil islands adjacent to the navigation channel exert a "tremendous influence" on the wave characteristics of the bay. Waves crossing the spoil mounds interact with the bottom and break, thus acting as an offshore breakwater offering protection to the west shore of Maumee Bay when waves are from the east or northeast and for the south shore when waves are from the north or northwest. Benson also stated that the subaquaeous portion of the Cedar Point spit, including Turtle Island, can influence wave activity within the bay by buffering large open lake waves from the north and northeast.

Soils

Soil, the thin weathered zone at the surface of the islands, is formed at the top of either bedrock or overlying till, clay, or gravel, whichever is present at the surface. Soil is capable of supporting plant life and it should not be confused with these non-productive deposits of till, clay, or gravel. The nature of the soil that has developed in the islands is a product of five factors: climate, parent material, topography, effects of organisms (both plant and animal), and the variations in these factors throughout the time through which the soil has been forming (Forsyth, 1965). Most important of these five factors in the islands region is parent material or geological substrate, which may be limestone or dolomite, glacial till, lacustrine sediments, or ancient beach gravel, although topography is locally important where it affects soil moisture.

Soils mapping of the island area by the U.S. Soil Conservation Service is available for both Ottawa (Paschall, et al., 1928) and Erie counties (Redmond, et al., 1971). Many changes in soils terminology have taken place since the publication of the older map. A generalized

interpretation of the modern mapping of the soils on the islands is presented in Figure 6 and Table 12 following the modern soil revisions tabulated by Hamilton and Forsyth, (1972). The following description of the major soils groups in the island region was prepared by Dr. Jane L. Forsyth, Bowling Green State University:

Romeo soils. This group occurs in areas of shallow limestone or dolomite, where exposures of bedrock are common. It is a rich, dark, organic soil, with a loose, crumbly structure, which is high in nutrients and has relatively good moisture-holding capacity where undisturbed (Lutz and Chandler, 1946). It is easily destroyed by fire or by drying and erosion where vegetation has been cleared. Because of the extensive disturbance in most areas of the islands, this soil is commonly quite thin. In mature woods, on the other hand, this soil may be as much as a foot or more thick, though its average depth is not easily determined because of the irregular, pinnacled surface on the soluble limestone or dolomite on which the soil occurs.

Two different soils, the Hoytville clay loam and the Pyrmont silt loam, have been developed in the glacial till of the Erie Islands. These soils differ in the amount of clay they contain and in the islands on which they occur.

Hoytville soils. This group was formed in the clay-rich till of the Bass Islands and appears as a dense, heavy clay loam with scattered pebbles and sand grains. As a result, water moves through the soil extremely slowly. Such areas can be identified by the presence of standing water after a heavy rain. The color of this soil is generally dark gray, a result of long-continued organic accumulation and lack of oxidation. An example of such an area on South Bass Island is the box-elder woods along the road at the northeast end of the island (McCormick, 1968; Hamilton and Forsyth, 1972).

Pyrmont soils. This group was formed in the till on Kelleys Island that is not so clayey as is the till in which the Hoytville soil was formed. Because this soil contains less clay, it is somewhat better drained, and only very rarely does water stand on the surface. The topsoil is gray, with a somewhat looser texture than that of the Hoytville, and the subsoil, which is more clayey than the topsoil, is not as heavy and is browner in color.

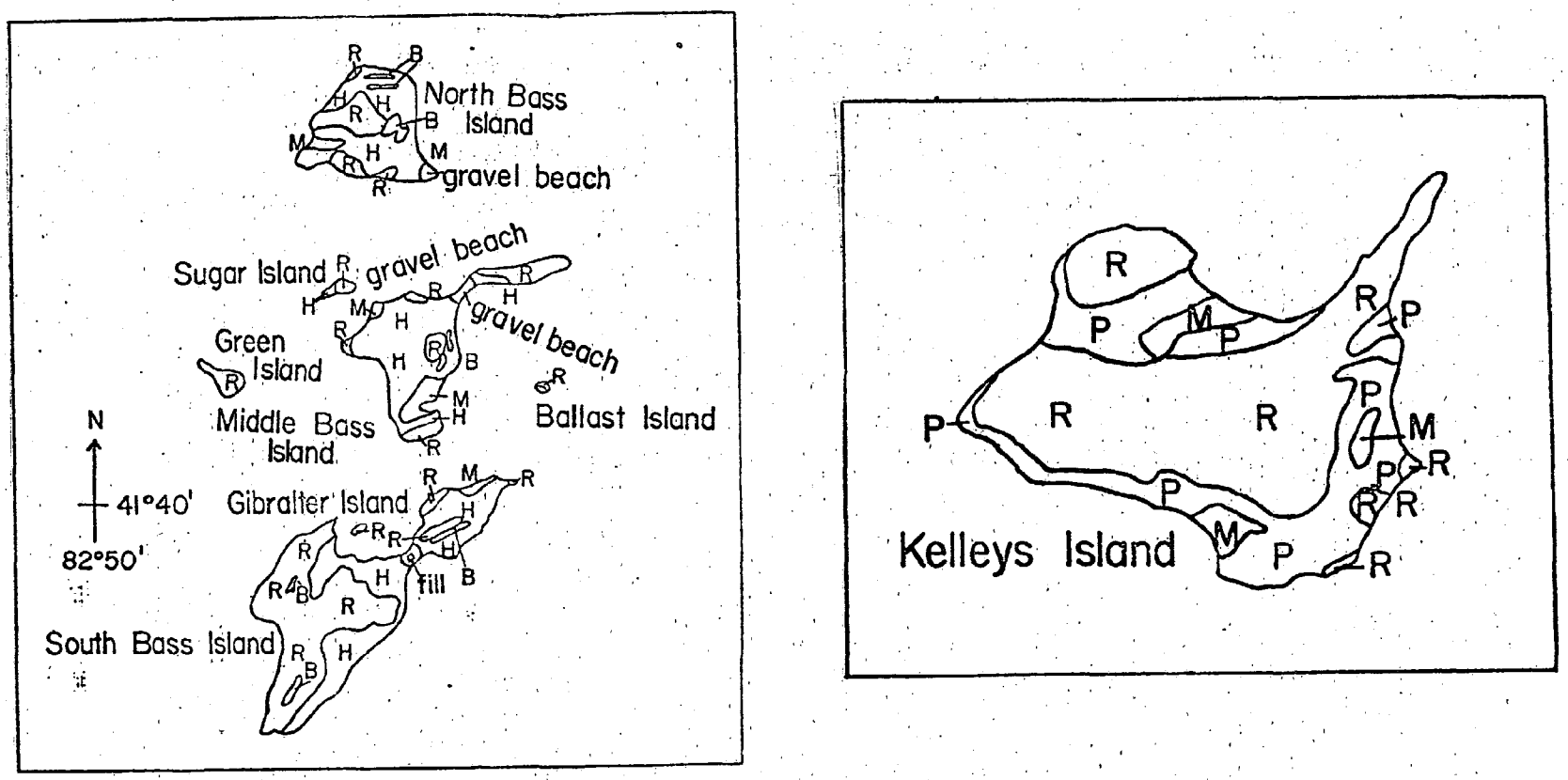


FIGURE 6. GENERALIZED MAP OF SOILS ON THE BASS ISLANDS (Paschall, et al., 1928, and updated according to information provided by Donald Urban and Charles Innis of the U.S. Soil Conservation Service) AND KELLEYS ISLAND (Redmond, et al., 1971). Symbols for soils are: R - Romeo, H - Hoytville, M - Mermill, B - Belmore, and P - Pyrmont.

TABLE 12

GENERALIZED GROUPS OF SOILS ON THE LAKE ERIE ISLANDS

Symbols on Figure 6	Modern Soil Name	Old Terminology	Parent Material	Representative Locations
M	Mermill	Catawba silt loam	lacustrine silt	This group occurs in small local areas on the larger islands; especially in low areas and near swamps adjacent to ponds.
	(Also includes Haskins loam, Seward fine sandy loam, originally called Catawba fine sandy loam, and possibly some Toledo clay loam.)			
B	Belmore loam	Rodman gravel	gravel bars	This group is only recognized where associated with a few small narrow low ridges on the Bass Islands; on South Bass Island in the field adjacent to and also in the cemetery at the south end, in the field southwest of Verduin residence on Mitchell Avenue (mostly excavated away), and just east of the main road on the north end; on Middle Bass Island in very small, very local spots on the east side; and on North Bass Island on the east and north sides.
	(Also includes Rawson gravelly loam, originally called Catawba gravelly loam.)			

TABLE 12 (Continued)

GENERALIZED GROUPS OF SOILS ON THE LAKE ERIE ISLANDS

Symbols on Figure 6	Modern Soil Name	Old Terminology	Parent Material	Representative Locations
R	Romeo stony loam	Randolph stony loam	shallow limestone or dolomite bedrock	This group is very common on all islands: along northwest cliffs and rocky outcrop areas inland on South Bass Island; south shore, east-central area, and northeast point on Middle Bass Island; and on north shore and throughout middle of Kelleys Island.
	(Also includes Milton silt loam)			
H	Hoytville clay loam	Catawba loam	clay-rich till	This group has moderate extent on the Bass Islands; particularly on the northeast end of South Bass Island; the west-central part of Middle Bass Island; and much of North Bass Island.
P	Pyrmont silt loam	none	loamy till	This group is found on Kelleys Island; in moderate-sized areas in the east-west lowland near the north shore and along the south and southeast shores.

Mermill soils. This group was developed in thin lacustrine silt or fine sand lying on till, the soil profile locally extending downward into the underlying till, but to the untrained eye, it does not appear to differ greatly from either the Pyrmont or Hoytville soils. The Mermill soil has a gray-brown topsoil that is less clayey and less dense than the Hoytville, and it lacks the pebbles found in the Pyrmont soil. The lacustrine silts in which this soil was developed are probably thickest in the swampy flats of northeastern Pelee Island and adjacent to some of the swamps around the edges of the ponds on Middle Bass, North Bass, Kelleys, and Pelee Islands.

Belmore soils. This group was developed in the gravel of ancient cobble beaches and is restricted to a few small linear belts on the Bass Islands. The soil appears as a very dark-brown gravelly loam, grading down into a loam containing increasing numbers of cobbles (Paschall, et al., 1928). Where the soil has been plowed or otherwise disturbed, scattered cobbles may sometimes be present on the surface, but deep plowing or local excavation may also expose the underlying till. The Belmore soil is fairly rich but its porosity tends to make this soil very droughty. The best example of Belmore soil occurs on the gravel ridge at the southwest end of South Bass Island.

Caves and Minerals

The Lake Erie islands, including Catawba and Marblehead, possess a rather unusual cave and sinkhole topography. The carbonate bedrock of these islands is soluble in weak, naturally-occurring acids, such as carbonic acid and various organic acids. These acids have slowly dissolved portions of the rock producing caves, sinkholes and other solution features. This process has taken place for millions of years, starting soon after the time when the lime muds which had accumulated in the ancient ocean were drained of sea water. The solution process initially resulted in sinkholes which became filled with dolomite fragments that had broken off the rim, producing a rock called breccia. Exposures of these ancient breccia-filled sinkholes are common on the west shore of South Bass Island.

Solution has also occurred more recently, producing many small caves in the bedrock. Thirty seven such caves have been reported for the islands. The general locations of caves on South Bass, Green and Catawba Islands are shown on Figures 7 and 8. Most of the caves are the result of solution and then the collapse of the surrounding and

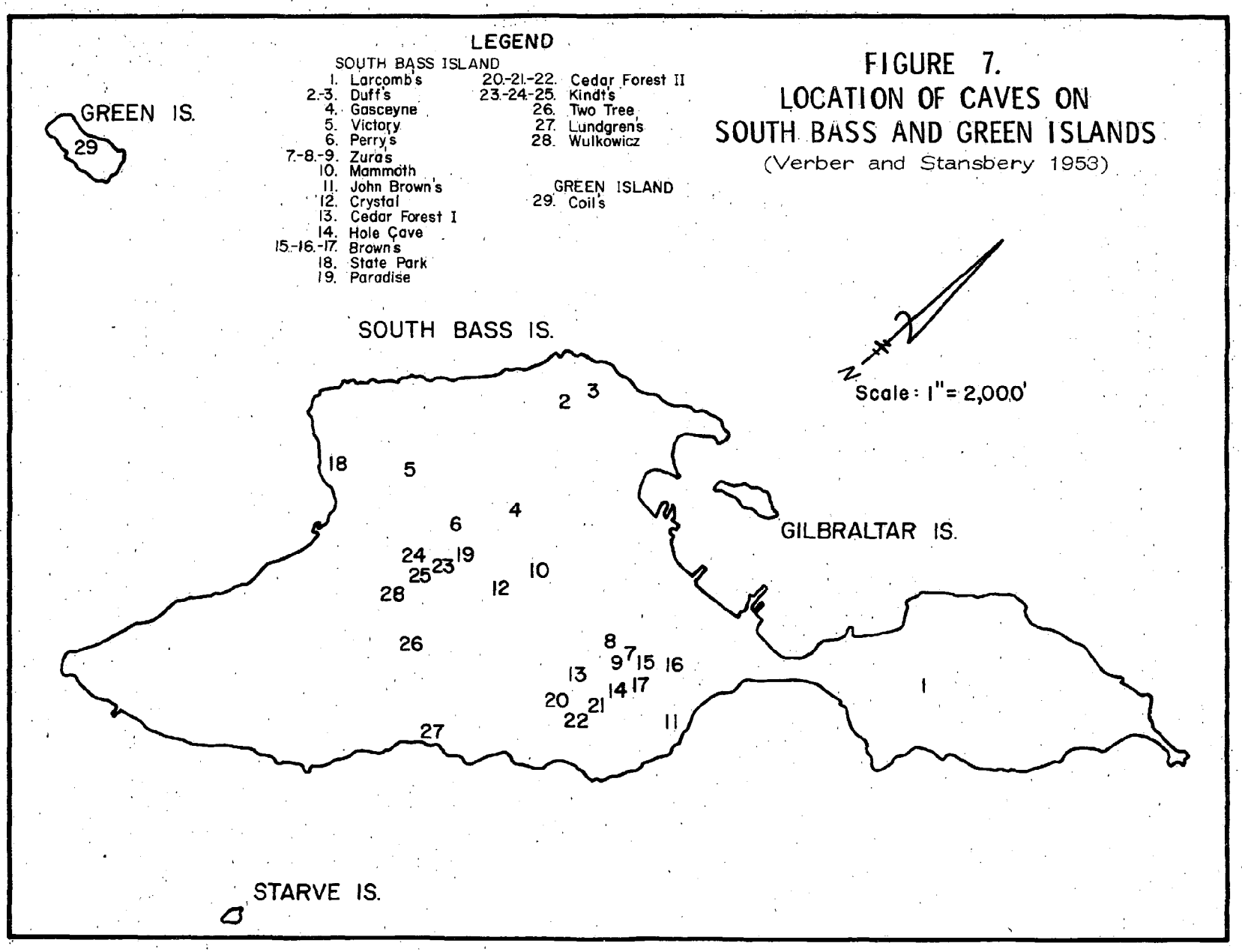
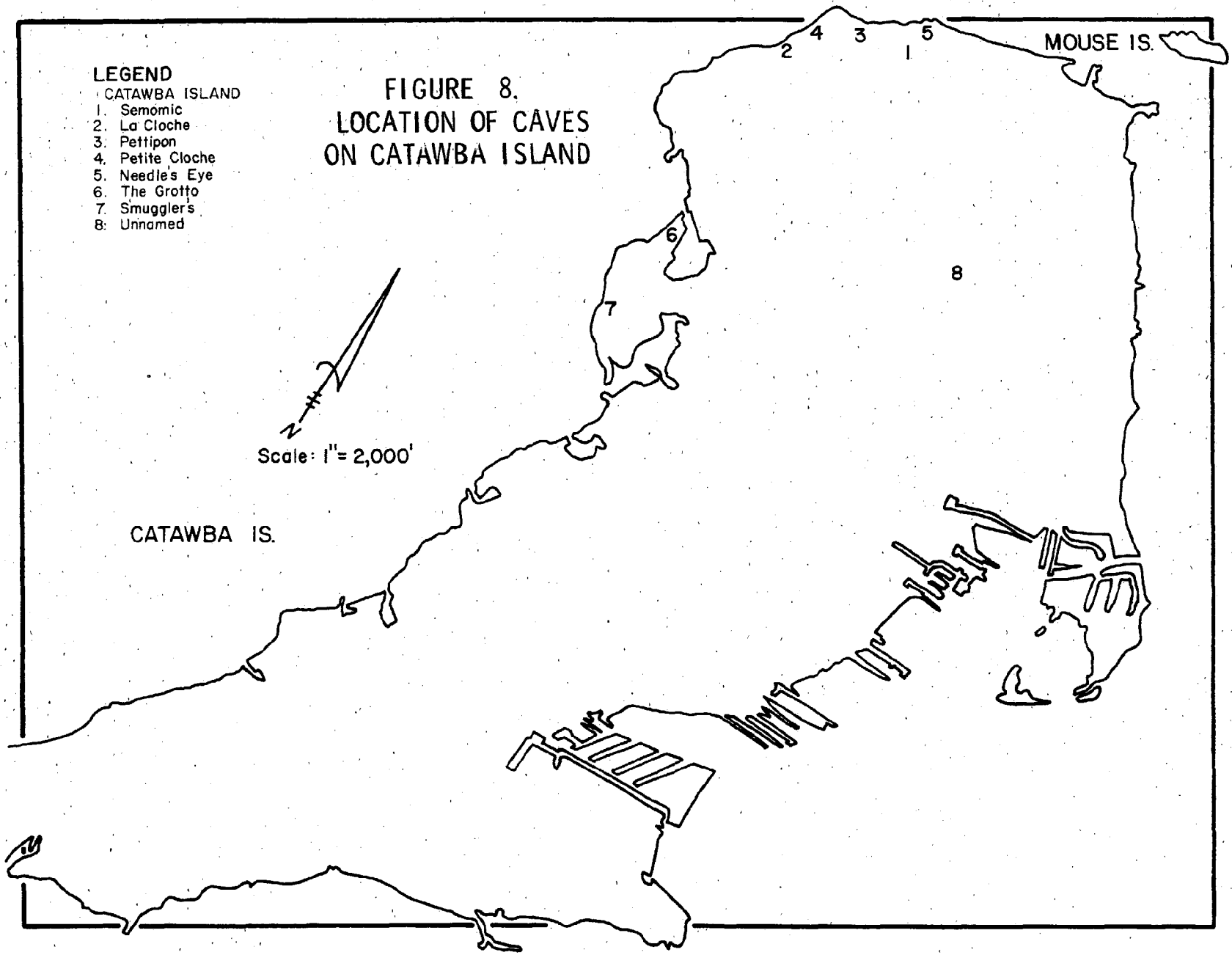
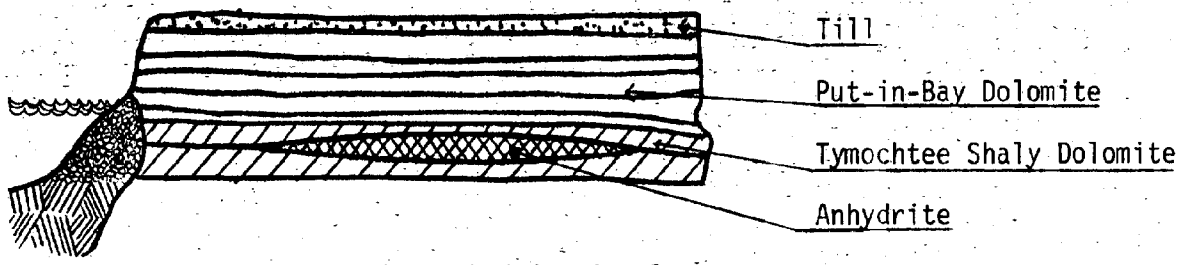


FIGURE 7.
LOCATION OF CAVES ON
SOUTH BASS AND GREEN ISLANDS
(Verber and Stansbery 1953)

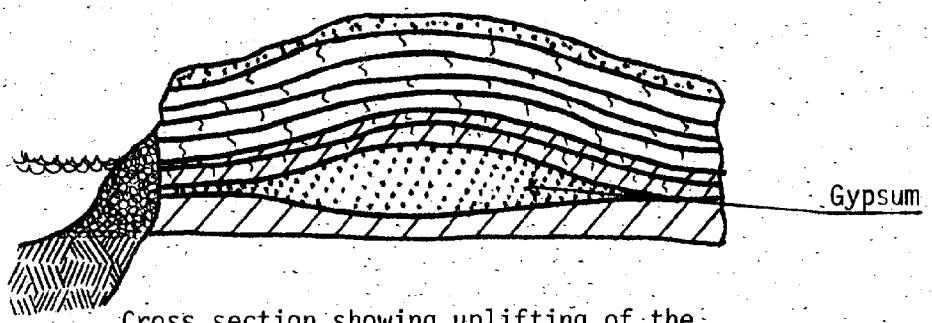

LEGEND
CATAWBA ISLAND
1. Semomic
2. La Cloche
3. Pettipon
4. Petite Cloche
5. Needle's Eye
6. The Grotto
7. Smuggler's
8. Unnamed
FIGURE 8.
LOCATION OF CAVES
ON CATAWBA ISLAND
MOUSE IS.
CATAWBA IS.
Scale: 1"= 2,000'
1
2
3
4
5
6
7
8

overlying rock into the void. The exact origin of the caves and sinkhole features has been a matter of speculation. The most widely accepted theory of formation has been advanced by Verber and Stansbery (1953). The theory states that the structure of the rock materials combined with their mineral composition and contact with water has probably resulted in cave and sink formation (Figure 9). Specifically, the Put-in-Bay Dolomite is underlain by the Tymochtee Formation which contains lenses or pockets of anhydrite gypsum. At some time in the past, water filtered down through the surface materials, the Put-in-Bay Dolomite and eventually into the Tymochtee anhydrite gypsum. Anhydrite gypsum has the property of swelling when in contact with moisture. Hydration increases the volume from 33 to 63 percent. The drastic increase of volume exerted approximately one ton of pressure per square inch on the surrounding materials. Such pressure caused a doming of the overlying Put-in-Bay rock structure. Later, the gypsum was dissolved away by solution leaving a large unsupported subterranean cavern. Eventually, the roof of the cavern collapsed, forming crescent shaped caves and caverns around the perimeter. The collapse generally formed large shallow circular depressions on the land surface and created small caves around the margins of these collapse features. In areas of Catawba and Marblehead, the lenses of anhydrite may have been thinner and less extensive producing only a slight doming, and eventually resulting in the formation of a sinkhole rather than a cave. The lower levels of many of the caves, formed either by solution or collapse, are now flooded by water coming in, along cracks and solution openings, from the lake and thus causing ground water pollution problems. Perry's Cave on South Bass Island is the only cave of this type open to the public.

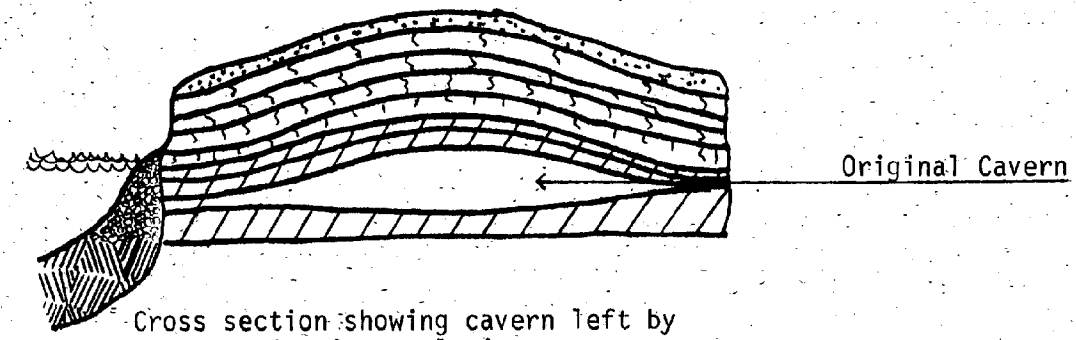
Crystal Cave is the most unusual cave on South Bass Island because of its mineral deposits. The walls are completely covered to a thickness of two feet by beautiful blue celestite crystals ($SrSO_4$). These are very large, usually ranging from eight to fifteen inches in length and are tabular in form. The appearance of the interior of this cave is that of an immense geode. This cave was discovered by Gustav Heineman in 1891 while digging a water well. The cave is about 30 feet below ground level and consists of two small connected rooms. It had an original height of about three feet; crystals removed from the floor when the cave was deepened were sold to fireworks manufacturers for the strontium (White, 1926). Crystal Cave is open to the public during summer months.



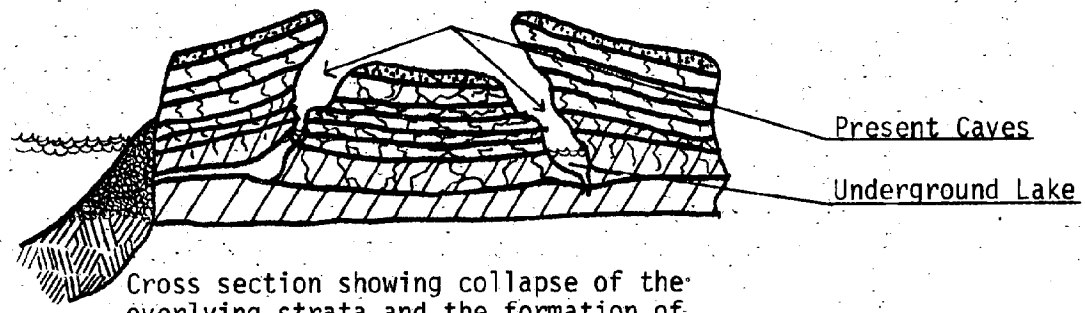
Cross section showing anhydrite in place.



Cross section showing uplifting of the overlying strata by the anhydrite hydration into gypsum.



Cross section showing cavern left by gypsum going into solution.



Cross section showing collapse of the overlying strata and the formation of new caves around the edges.

FIGURE 9. FORMATION OF CAVES ON THE LAKE ERIE ISLANDS (Verber and Stansbery, 1953).

In discussing the mineral deposits of the Lake Erie islands, Langlois and Langlois (1948) state:

> "Large crystals of strontium sulphate ($SrSO_4$, celestite) occur in masses in some known local areas. Strontian Island was the name applied at one time to the present Green Island, and an open pit there reveals the source of supply of some crystals which were used in clarifying sugar and for fireworks. On South Bass Island crystals are exposed in many places, but the greatest known mass of them occurs underground. This mass lines the inner surface of a geode, and, since it has steps leading down into it, and is illuminated, it can be seen from the inside. Known as "Crystal Cave", it has been shown to visitors each summer since about 1895. Perry's Cave is one of the largest of numerous openings in the dolomite, and it has been a showplace since 1869."

Crystal and Perry's Caves are the only caves on the Lake Erie islands presently open to the public.

Dr. David H. Stansbery of The Ohio State University prepared the following annotated list of minerals occurring on South Bass Island:

Celestite. The most abundant island mineral appears to be celestite, the most spectacular deposit being that in Crystal Cave at the Heineman Winery. Here it occurs as large bluish transparent crystals, some exceeding 15 inches in length and 3 inches in thickness. Smaller crystals of the same type are found at several places along the west shore and in at least one of the other island caves. Several specimens taken from Kindts' Cave were covered with a thick layer of travertine and would have been unidentifiable to the eye but for the characteristic crystaline form. Celestite also occurs as large white concretionary masses in the massive stratum of dolomite exposed on the cliff face of the west shore. The mineral here is of a fibrous texture and usually milky opaque. Many of these latter deposits measure several feet in diameter and appear to be or have been almost spherical. Several smaller celestite concretions collected along the west shore contained small bright yellow crystals of native sulphur.

Calcite. This mineral assumes a variety of forms on the islands. It is usually found as "dog tooth spar" lining the inner walls of fractures and pockets exposed along the shore. Some specimens

exhibit all-but-transparent hexagonal crystals while others are opaque granular masses. At one site on the southeast shore clear calcite has filled several exposed joints, and a number of perfect cleavage rhombs of the mineral have been taken there. This locality may be easily located by following the beach until one finds water-worn snow-white pebbles of this mineral.

Barite. Only one barite deposit of appreciable magnitude has been discovered on the island. The crystals here are small (0-5 mm), numerous and milky white. They have been found encasing calcite crystals indicating that they were formed after that mineral. This deposit is located in the massive dolomite stratum along the west shore just north of the present state park. Many specimens of very small transparent barite crystals have been collected along the southern portion of the west shore but they were mostly isolated deposits no larger than 3 cm in diameter.

Quartz. In several of the thin bedded strata of dolomite along the west shore numerous small cherty concretions have been found. While most of these quartz deposits appear to contain a large percentage of impurities, several held small transparent quartz crystals. One such geode held crystals of translucent blue amethyst. Several specimens of transparent quartz crystals have been found along the west and south shores, but none over 2 mm in length.

Epsomite. One might expect water soluble minerals to be absent in a bedrock so extensively jointed. A single deposit of epsomite was found, however, in a sheltered pocket in the west shore cliff near the base of the Victory Anticline. Several quart jars of this brittle fibrous white mineral were removed from the recessed deposit with a spoon. The cliff at this site is periodically drenched with the water from breaking waves during storms. In view of this, it seems likely that the epsomite may be deposited here between storms by local evaporation of mineral bearing ground water.

Travertine. Many of the island caves exhibit stalactitic formations of several varieties. Not only is travertine present as stalactites and stalagmites but portions of several cave floors are covered with this "flow stone". Travertine may also be found under some overhanging rock ledges along the shore.

Marcasite. The Tymochtee Dolomite at the base of the Victory Anticline at South Bass Island State Park has included within it small marble-sized aggregations of silver-green cock's comb crystals of marcasite. This mineral, one of the iron sulphides, somewhat resembles iron pyrite (fool's gold) in hardness, color, and acid solubility. Both give the odor of sulfur when struck with a hammer but their crystalline structure is distinctly different. Perfect crystals were recovered from the dolomite by dissolving the surrounding matrix in an acid solution. Iron pyrite was not found in this study. Marcasite, however, was located at several places in the cliff side between the state park and the south point light.

Other Minerals. A thorough search of the island caves and outcrops failed to reveal any gypsum deposits although it has been found at a depth of 60-100 feet in island well drilling operations. Specimens of selenite and fluorite have been found on the island, but so far as I can determine, never in the bedrock. Fluorite of the type found has been recorded for nearby Rattlesnake Island (Newberry, 1873) and several fine specimens were collected from that island in 1955. Gilbert (1873) reported selenite for West Sister Island. Other minerals of igneous and metamorphic origin have been found in the glacial till but these have not been observed in the bedrock. I assume, therefore, that they were transported to the island from the Canadian shield by glaciers some 12,000 or more years ago.

The manner of deposition of the island's native minerals remains to be solved. Newberry (1873) suggested deposition by thermal springs but this does not seem likely in view of several facts which have been discovered within the past half century. At the time of Newberry's survey the nature of the deep-lying rock strata beneath Ohio's broad expanse of sedimentary deposits was not known. It was perhaps assumed that igneous masses of a molten or near-molten state lay just beneath a relatively thin sedimentary crust. Well records (Hubbard, 1932) have since shown that the first non-sedimentary rocks lie 3,000 to 4,000 feet below the surface in Ohio. These rocks are metamorphic in nature and lie immediately beneath sedimentary strata which have not been metamorphosed. It seems unlikely that mineral bearing springs would rise from such a great depth in view of the fact that those strata lying just above the metamorphic rocks have not been so altered. This indicates that the underlying rocks were formed and modified before the deposition of the overlying sedimentary strata.

HYDROLOGY OF THE LAKE ERIE ISLAND REGION

Water Circulation

Circulation in western Lake Erie is dominated by the large inflow of water from the Detroit River (mean flow approx. 210,000 cfs), particularly west of the islands. The midchannel flow of this river penetrates deep into the western basin, with a branch that flows eastward toward Pelee Passage on the north side of Pelee Island. Eddies occurring on the sides of the Detroit River result in sluggish movement that causes the water to cling to the shoreline. Adjacent to the Michigan, and to a lesser extent the Ontario side, these eddies tend to retain the water, causing a high concentration of contaminants. The Maumee River, with an average flow of 4,700 cfs, is the second largest stream flowing into the lake and carries 37% of the sediment loading to the lake but accounts for less than 3% of the total water drainage to Lake Erie.

East of the dominating effect of the Detroit River, the prevailing southwest winds produce a clockwise surface flow around the islands. However, this surface flow is often altered by changes in the direction, intensity and duration of the wind. Strong winds from any direction can drive the surface currents over most of the basin toward the windward shore.

Bottom currents have essentially the same pattern as surface flow in that part of the western basin influenced by the Detroit River. However, in other parts of the basin bottom currents are commonly the reverse of and compensate for strong wind-driven currents. Current meter data indicate that bottom currents in the vicinity of the islands form a counter-clockwise gyre to balance the clockwise surface flow (Herdendorf, 1975). Both the surface and subsurface rotary flows in the island region appear to circulate clearer, cooler central basin water into the adjoining part of western Lake Erie.

The characteristics of the major currents in western Lake Erie are outlined in Table 13. Water level fluctuations, seiches, waves and alongshore currents are discussed in the Shore Erosion section of this report. The hydrography of the western basin, including the reefs and islands, is presented in the Geology section.

TABLE 13

CHARACTERISTICS OF MAJOR CURRENTS IN WESTERN LAKE ERIE[1]

I. Horizontal circulation

A. Natural flow (hydraulic current)

1. Is a result of hydraulic gradient from west to east.
2. Has net eastward movement (unidirectional throughout water column).
3. Has low velocity (maximum estimate: Verber (1952) for western basin, 0.15 ft./sec.)
4. Has no compensating return flow.
5. Has other currents superimposed on it, often masking natural flow.
6. Is important in distribution of dissolved substances (84 percent introduced at its source).
7. Is unimportant in transport of suspended material except in restricted channels.

B. Wind driven currents

1. Are caused by wind stress on water surface.
2. Are variable in direction.
3. Have high velocity (up to 2.0 ft/sec).
4. Move large volumes of water in short period of time (wind tide and wind setup).
5. Have subsurface return flow often associated.
6. Are modified by geostrophic deflection, remnant currents, basin topography, air and water temperatures, and characteristics of the wind.

C. Alongshore (littoral) currents

1. Are generated by breaking waves in the nearshore zone.
2. Have movement generally parallel to shoreline (controlled by nearshore topography).
3. Have direction at an angle to wind or wave progress.
4. Have rapid velocity (up to 4 ft/sec).
5. Are capable of transporting sand- and gravel-sized particles (littoral drift).
6. Dissipate rapidly when storm subsides.

D. Seiche currents

1. Are created by standing wave motion of seiches (oscillating waves without progression).

TABLE 13 CON'T.

CHARACTERISTICS OF MAJOR CURRENTS IN WESTERN LAKE ERIE[1]

2. Are degenerated by friction (seldom complete because of modification or rejuvenation).
3. Have minimum velocity at area of maximum amplitude.
4. Have maximum velocity at nodal zone.
5. Accomplish no net transport of water (balanced by to-and-fro motion).

II. Horizontal and vertical circulation
   A. Density currents
      1. Are the result of density differences between lake water and inflowing water.
      2. Have density differences caused by temperature, and by dissolved solid content and suspended material content differentials.
      3. Provide mechanism for rapid distribution of tributary inputs.
      4. Under-run lake water when water is cooler and solids-laden (turbidity current).
      5. Can over-ride lake water when warmer if solids content is not too high.
      6. Have movement lakeward with no compensating return flow of same water (thermal bar, Rodgers, 1965).

   B. Turbulence
      1. Has random motion with horizontal and vertical components.
      2. Is associated with other types of currents (particularly pronounced with wind-driven and wave-generated currents).
      3. Is effective in mixing and dispersing water masses.

III. Vertical circulation
   A. Temperature gradient currents
      1. Are caused by heat transfer (convection cell).
      2. Are most important during cooling period (September to January) and warming period (March to June).

TABLE 13 CON'T.

CHARACTERISTICS OF MAJOR CURRENTS IN WESTERN LAKE ERIE[1]

3. Are characterized by cooled surface water sinking as warmer water rises to replace it, a process that continues until water column reaches temperature of maximum density (4° C) or by lakeward progression of a thermal bar as the lake is warmed.

B. Sinking and upwelling currents
   1. When sinking, are caused by convergence of horizontal currents, forcing a downward movement to balance the water level.
   2. When upwelling, are caused by divergences of horizontal currents, resulting in an upward movement to balance the water level.

[1] after Herdendorf (1975)

Inflow and Discharge

The Lake Erie basin, exclusive of drainage from the upper lakes, comprises about 34,000 square miles, of which nearly 10,000 square miles are lake surface. The lake receives an average replenishment of approximately 219,000 cfs of water from tributary streams and precipitation over the lake (Table 14). Approximately 90 percent of stream flow or 80 percent of the total replenishment comes from the Detroit River, the drainage outlet for Lake St. Clair and the upper lakes. The average discharge of the Detroit River, as gaged by the U.S. Lake Survey, is 176,000 cfs, equivalent to 20.9 feet of water over the surface of the lake per year. Surface runoff from the other streams in the basin is estimated at 20,000 cfs, which represents about 25 percent of the overland precipitation, while overlake precipitation is 23,000 cfs. Runoff and overlake precipitation together yield an equivalent of 4.3 feet per year over the lake surface.

The storage capacity of Lake Erie is approximately 2.5 times the average annual inflow. The shallow western basin has a volume of 5.8 cubic miles and a retention time of 45 days; the central basin has a volume of 71.8 cubic miles and a retention time of 559 days; and the deeper eastern basin has a volume of 36.4 cubic miles and a retention time of 283 days.

Discharge from Lake Erie is through the Niagara River at Buffalo and the Welland Canal diversion at Port Colborne. Combined outflow averages 202,000 cfs, annually equivalent to 23.3 feet of water over the lake. Evaporation accounts for between two and three feet of water loss annually from the lake surface.

The water budget for Lake Erie can be summarized as follows: (1) the Detroit River supplies 80 percent of the water to the lake, precipitation on the lake surface 11 percent, and stream runoff 9 percent; (2) annual evaporation nearly equals precipitation on the surface of the lake and exceeds runoff, exclusive of the Detroit River flow; and (3) loss of water from the lake is about 90 percent outflow and 10 percent evaporation.

Water Temperature and Lake Ice

Water temperatures in Lake Erie undergo wide seasonal fluctuations, ranging from 33°F in the winter to about 75°F in late summer. During severe winters, such as 1976-1977, up to 95 percent of the lake is ice covered. Frequently the western basin freezes across, but only rarely

TABLE 14
RUNOFF DATA FOR TRIBUTARY STREAMS TO LAKE ERIE*

	Drainage Area (sq. mi.)	Average Discharge (cu.ft/sec)	Estimated Suspended Solids (tons/year)	Estimated Dissolved Solids (tons/year)
Streams in Michigan				
Detroit River	------	176,000	1,570,000	33,580,000
Huron River	890	570	1,800	73,000
Raisin River	1,020	673	4,700	91,200
Others	1,200	720	4,000	25,000
Streams in Ohio				
Ottawa River	180	119	1,000	5,000
Maumee River	6,586	4,740	2,270,000	1,370,000
Toussaint River	108	76	700	4,000
Portage River	587	392	120,000	91,200
Sandusky River	1,421	1,060	270,000	446,400
Huron River	403	310	12,000	50,000
Vermilion River	272	218	9,000	40,000
Black River	467	388	15,300	66,400
Rocky River	294	275	29,500	131,400
Cuyahoga River	813	800	260,000	419,800
Chagrin River	267	315	35,000	90,000
Grand River	712	769	212,000	1,340,000
Ashtabula River	136	166	5,500	32,000
Conneaut Creek	192	235	4,000	20,000
Others	1,100	880	200,000	300,000
Streams in Pennsylvania				
Otter Creek	176	200	4,000	20,000
Others	193	219	4,500	25,000
Streams in New York				
Cattaraugus Creek	500	800	137,600	226,700
Buffalo River	375	545	74,500	357,300
Others	325	488	60,000	150,000

Table 14 (Continued)

	Drainage Area (sq. mi.)	Average Discharge (cu.ft/sec)	Estimated Suspended Solids (tons/year)	Estimated Dissolved Solids (tons/year)
Streams in Ontario				
Grand River	3,000	2,490	375,000	500,000
Others	3,160	2,530	350,000	450,000
Totals for Lake Erie Tributaries	24,357	195,978	6,030,100	39,857,400
Municipal and Industrial (outflow direct to Lake Erie)	------	-------	87,200	179,000
Precipitation over Lake Erie	9,919	23,300	---------	----------
Grand Totals for Lake Erie	34,276	219,278	6,117,300	40,038,400

* Data sources: U.S. Geological Survey; Ontario Water Resources Commission; Ohio Department of Natural Resources, Division of Water and; Federal Water Pollution Control Administration.

do the other basins freeze from shore to shore. The ice cover breaks up in March or April and gradual warming continues through the spring. Warming generally proceeds faster along the shore because of warm runoff water and, particularly along the south shore, because of the prevailing southwest winds which push the warm surface water to the right toward the south shore (geostrophic deflection). When the near-shore water has heated to the temperature of maximum density (39.2°F), a vertical thermal bar of water near that temperature forms a boundary between midlake waters that are less than 39.2° in temperature and the continually warming inshore waters (Rodgers, 1965). During a period of several weeks, as heating progresses, the thermal bar moves toward the middle of the lake in a contracting motion. As the bar moves offshore the midlake region remains nearly isothermal. In the central and eastern basins a thermocline (zone of rapid temperature decrease with increasing depth) develops in the region shoreward of the thermal bar. The thermocline separates the warmer epilimnion layer of the water from the deeper cooler hypolimnion layer.

Water Quality

The water of the western basin is usually uniform in temperature, top to bottom (isothermal), but because of its shallowness it responds more quickly to atmospheric temperature changes than the other basins. Occasionally in summer the basin stratifies thermally for short periods which deprives the lower layer of water a supply of oxygen from the atmosphere leading to rapid oxygen depletion near the bottom, drastically affecting bottom organisms.

Nutritional overenrichment is the single greatest water quality problem in western Lake Erie. Overenrichment has caused undesirable interference with water supplies, recreation, and fishing. Nutrients (such as phosphorus and nitrogen) are generally not harmful in themselves, but in excess they can result in tremendous overproduction of aquatic plants, especially the microscopic forms. Phosphorus concentrations in the western basin are often 20 times or more the amount needed to trigger offensive algal blooms (FWPCA, 1968). The common attached algae Cladophora grows in dense mats in the shallow rocky areas adjacent to many of the islands. Severe storms have broken these mats loose and washed them ashore to decay on the beaches. During low water periods (such as 1964) this has been a problem at Kelleys Island State Park by rendering the swimming beach unfit for bathers.

In general, the islands are far enough away from areas of industrial discharge and agricultural runoff that the levels of toxic substances, such as heavy metals and pesticides, in the water are low. Because of their locations in shallow bays near large communities, Johnson and Turtle Islands have the poorest surrounding water quality. Turbidity is also much higher in the bays than in the open lake. The water surrounding North Bass and Kelleys Islands is the clearest, at times having a transparency of up to 10 feet.

The most abundant chemical constituents of Lake Erie water are listed in Table 15 and shown graphically in Figure 10. Lake Erie waters are alkaline, having a total alkalinity of 95 ppm as $CaCO_3$ and an average pH of 8.3. Total dissolved solids in the water average 173 ppm, with the highest concentrations along the south shore. In general, the concentrations of the major cations and anions increase from west to east. Total dissolved solids, and calcium, sulfate, chloride, sodium, and potassium have all increased significantly in the past 50 years (Beeton, 1965). The rate of increase of the major ions is shown in Figures 11 and 12.

Dissolved oxygen in the surface water varies considerably depending on the time of day and the season of the year. It is supplied to the surface water by absorption from the atmosphere (aeration) and is transferred to the lower layers by mixing until the saturation level is reached for water of a particular temperature. Supersaturation can occur from a sharp increase in temperature or as a result of photosynthesis in aquatic plants. In the past 15 years several periods of temporary thermal stratification and accompanying low dissolved oxygen concentrations have been reported in the western basin of Lake Erie. Severe oxygen depletion has been observed since 1958 in the bottom waters of central Lake Erie during periods of stratification. Concentrations of less than 2 ppm have been found over extensive areas.

The following discussion outlines recent water quality trends in the western basin of Lake Erie. This information was derived from a three-year study (1973-1975) by the Center for Lake Erie Area Research (CLEAR) of The Ohio State University in cooperation with the U.S. Environmental Protection Agency. This study was undertaken to determine the effectiveness of water pollution abatement measures on controlling lake eutrophication.

TABLE 15

CHEMICAL CONSTITUENTS OF LAKE ERIE WATER

	Western basin[1]	Central basin[1]	Eastern basin[1]	Entire lake[1]	Water supply intakes[2]
Specific conductance (micromhos/cm at 25°C)	272	300	301	291	311
Dissolved solids (ppm)	162	178	179	173	182
Suspended solids (ppm)	19	7	9	12	---
Total alkalinity (ppm as $CaCO_3$)	94.2	95.5	96.5	95.4	132
Bicarbonate (ppm)	---	---	---	---	113
Calcium (ppm)	33.9	39.5	40.5	38.0	39.0
Chlorides (ppm)	21.3	24.5	24.5	23.4	24.0
Sulfates (ppm)	17.7	22.4	23.4	21.2	28.0
Sodium (ppm)	9.91	11.05	10.86	10.61	11.0
Magnesium (ppm)	8.7	10.0	10.0	9.6	8.6
Potassium (ppm)	1.47	1.31	1.34	1.37	(with sodium)
Silica (ppm as SiO_2)	1.20	0.68	0.47	0.78	2.0
Total nitrogen (ppm)	0.71	0.43	0.43	0.52	---
Ammonia (ppm)	0.159	0.086	0.086	0.110	---
Organic nitrogen (ppm)	0.36	0.25	0.24	0.28	---
Nitrate (ppm)	0.124	0.090	0.090	0.101	---
Iron (ppm)	---	---	---	---	0.04
Phosphate (ppm soluble PO_4)	0.032	0.010	0.010	0.017	---
Hydrogen-ion concentration (pH)	8.4	8.3	8.3	8.3	---
Chemical oxygen demand (ppm)	10.37	7.10	7.45	8.31	---

1. Average of chemical analyses of water from 1963 and 1964 Lake Erie cruises. Federal Water Pollution Control Administration (1968a).
2. Average of chemical analyses of water at 16 water supply intakes on the Ohio shore of Lake Erie, September 1950 to February 1952. Ohio Department of Natural Resources, Division of Water.

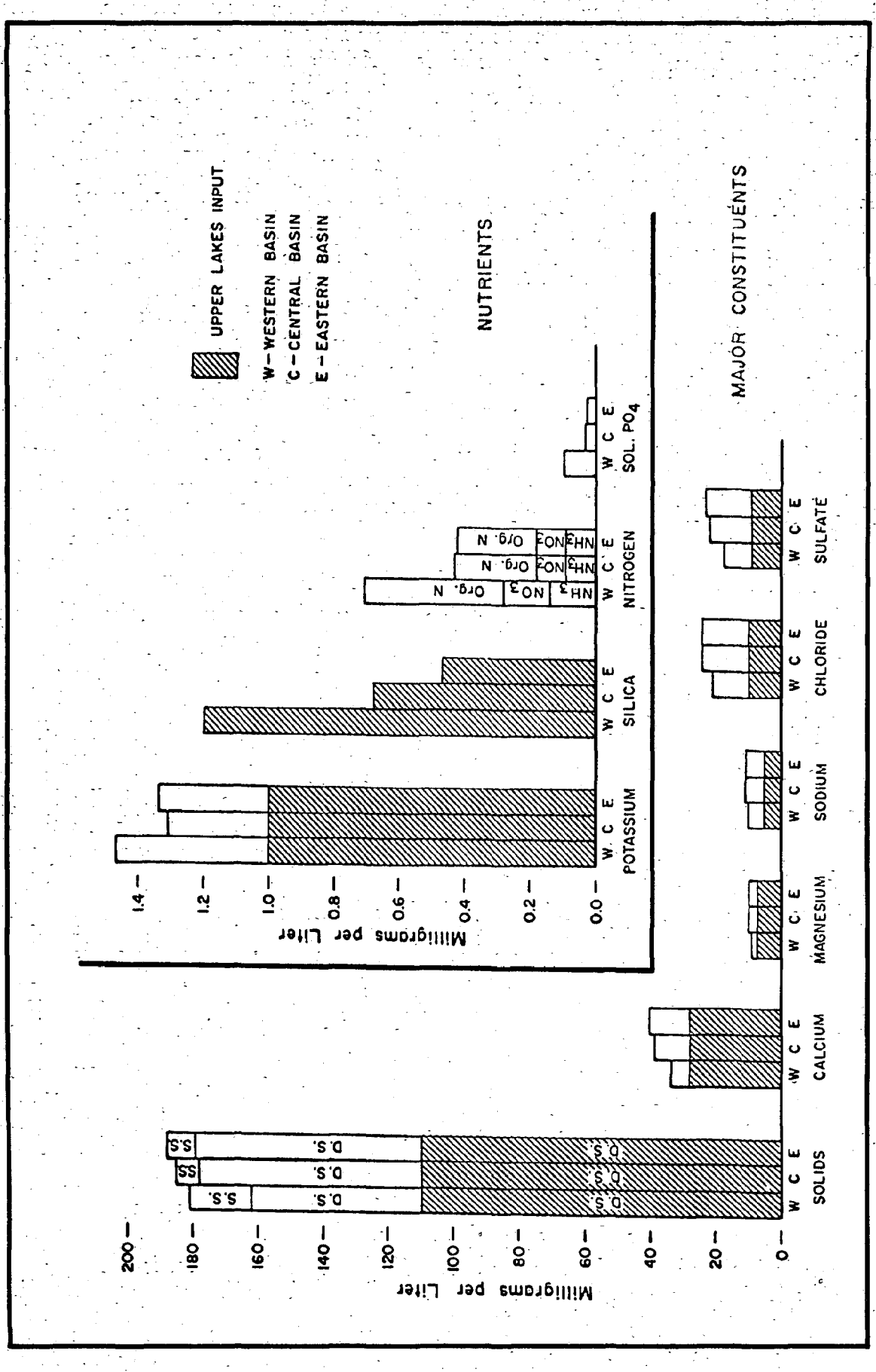


FIGURE 10. CHEMISTRY OF LAKE ERIE WATER (adapted from Federal Water Pollution Control Administration, cruise data) (FWPCA, 1968a).

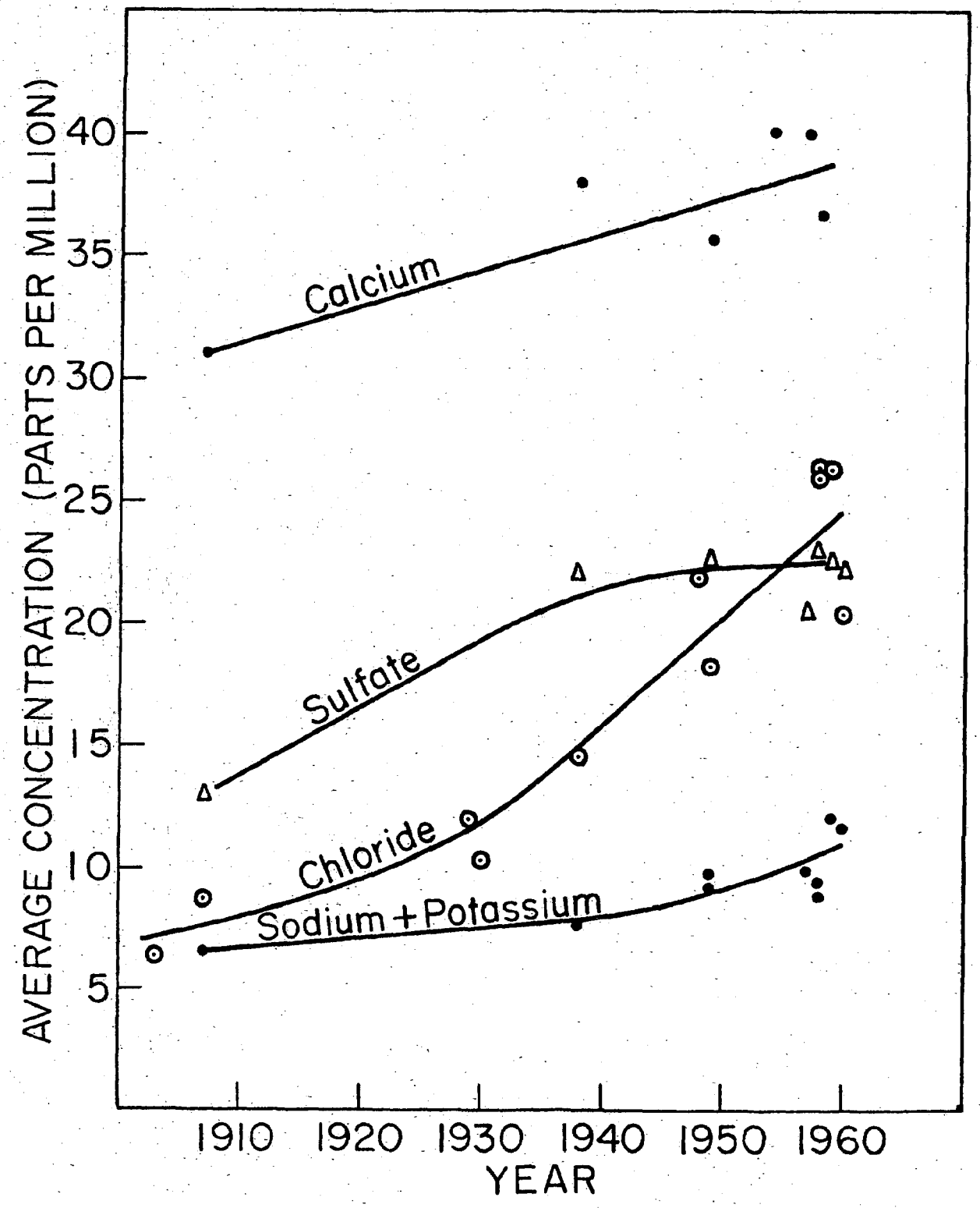


FIGURE II. CHANGES IN THE CHEMICAL CHARACTERISTICS OF LAKE ERIE WATERS (Beeton, 1965).

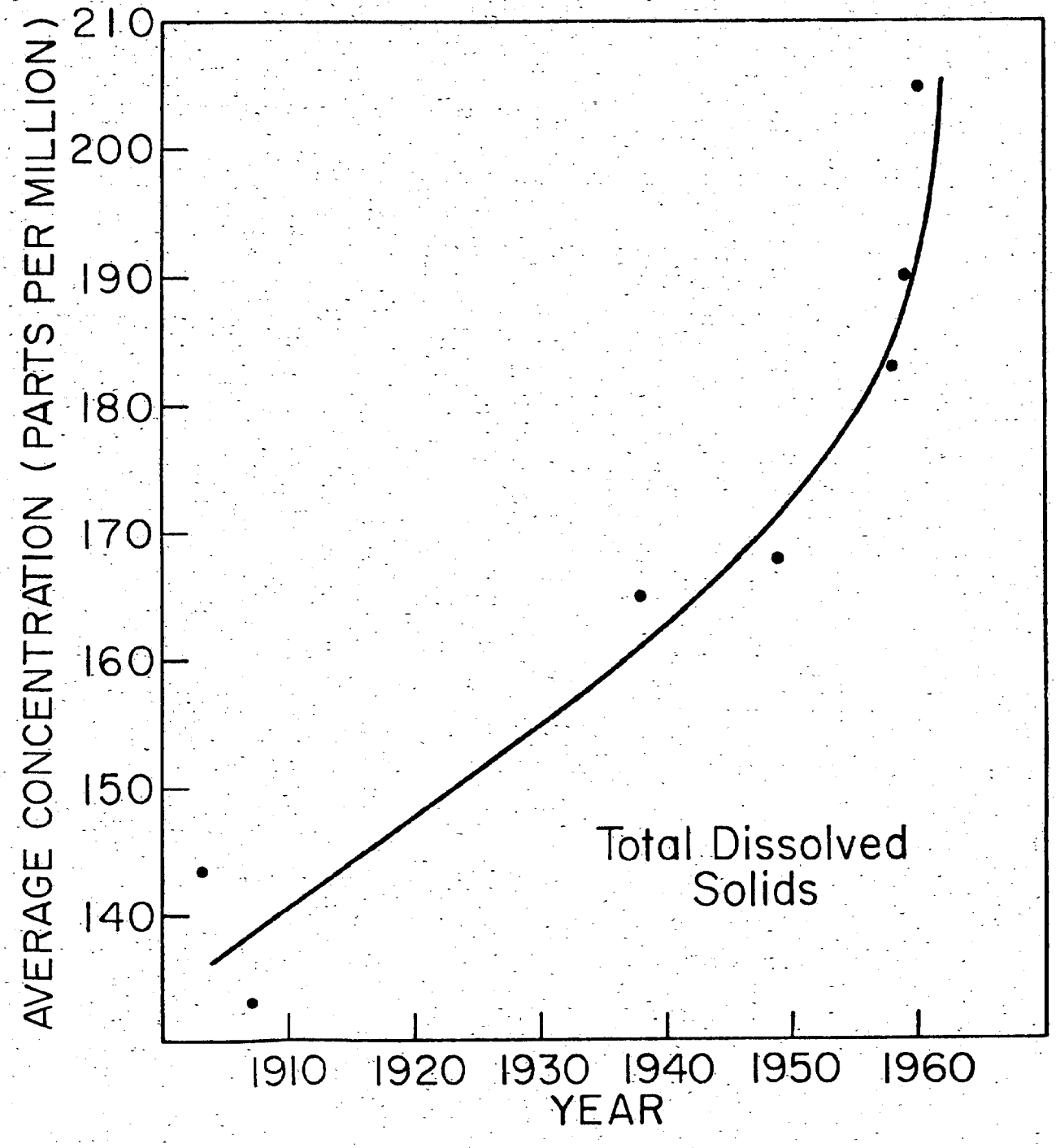


FIGURE 12. CHANGES IN THE CONCENTRATION OF TOTAL DISSOLVED SOLIDS IN LAKE ERIE (Beeton, 1965).

Dissolved oxygen. Concentrations of dissolved oxygen in the western basin of Lake Erie fell to less than 6 ppm (minimum safe level of sensitive fish species) from June to September during periods of temporary stratification. The condition effected over 50% of the basin. Carr et al, (1965) estimated that 5 days of stratification were required in 1963 to reduce oxygen concentration of portions of the western basin to 3.0 ppm, whereas, 28 days were needed in 1953. During a period of light winds, Britt (1955) reported an oxygen concentration of 0.1 ppm at a stratified station 2 miles west of South Bass Island. He associated this observation with a large reduction in the mayfly (Hexagenia sp.) population of this area. Later, Britt et al. (1968) reported (for the same area) a drop from 3.0 to 0.1 ppm (10-15 cm above the bottom) over the five day period 26 June to 1 July, 1966. Two CLEAR cruises (Figures 13 and 14) in 1973 show values of less than 3.0 ppm for a sampling horizon 1.0 m above the bottom. At these stratified sites the dissolved oxygen concentration rapidly fell below 1.0 ppm as the sensor neared the bottom. These areas of low oxygen were west and north of the sites sampled by Britt (1955). Additionally, unusually large quantities of silica, 21 July 1975. Although oxygen values ranged between 6 and 9 ppm at the time of the cruise, the presence of these nutrients indicates a probable regneration due to a prior anoxic condition.

Total phosphorus. In late April and early May 1974 the total phosphorus (TP) near the surface was fairly high, reflecting the turbid nature of the water containing phosphorus-bearing suspended particles. The western basin was strongly influenced by the Maumee River inflow, greater than 70 ppb, while the central basin except for near the Ohio shoreline was less than 20 ppb. By early June as the water cleared the phosphorus level dropped accordingly, ranging from 10-40 ppb. In mid-August the central basin continued to deliver high concentrations of phosphorus to the western basin, whereas the Detroit River mid-channel appeared to be contributing much less phosphorus to the lake. Storms in early September caused a peak concentration of phosphorus in the western basin and shallow western portion of the central basin. Concentrations greater than 90 ppm were measured in Maumee Bay. The eastern half of the central basin persisted with levels below 10 ppm. In late October, after overturn, mix mixing caused a general moderating of the phosphorus level by lowering the concentrations in the western basin and increasing them in the central basin.

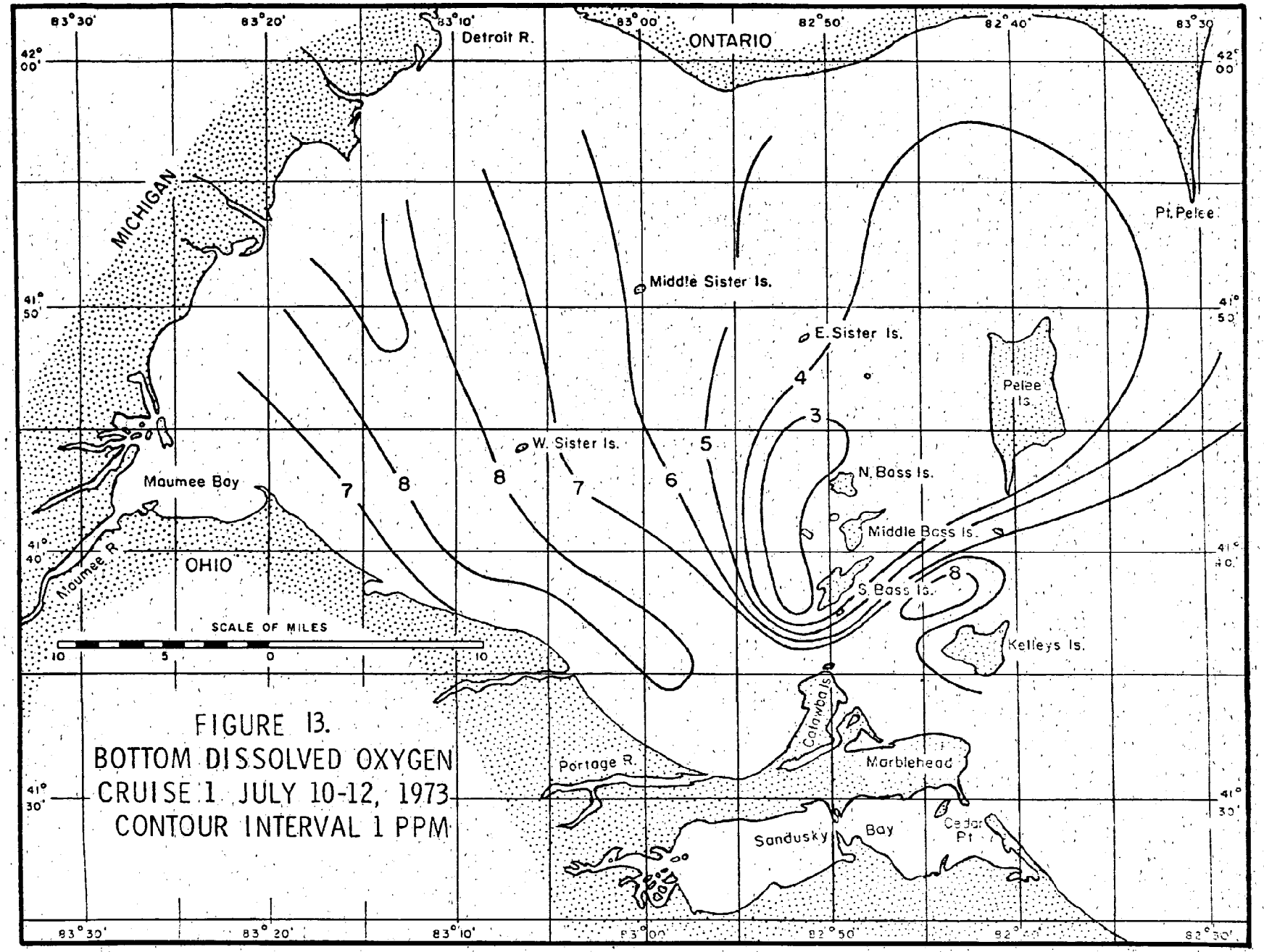


FIGURE 13.
BOTTOM DISSOLVED OXYGEN
CRUISE 1 JULY 10-12, 1973
CONTOUR INTERVAL 1 PPM

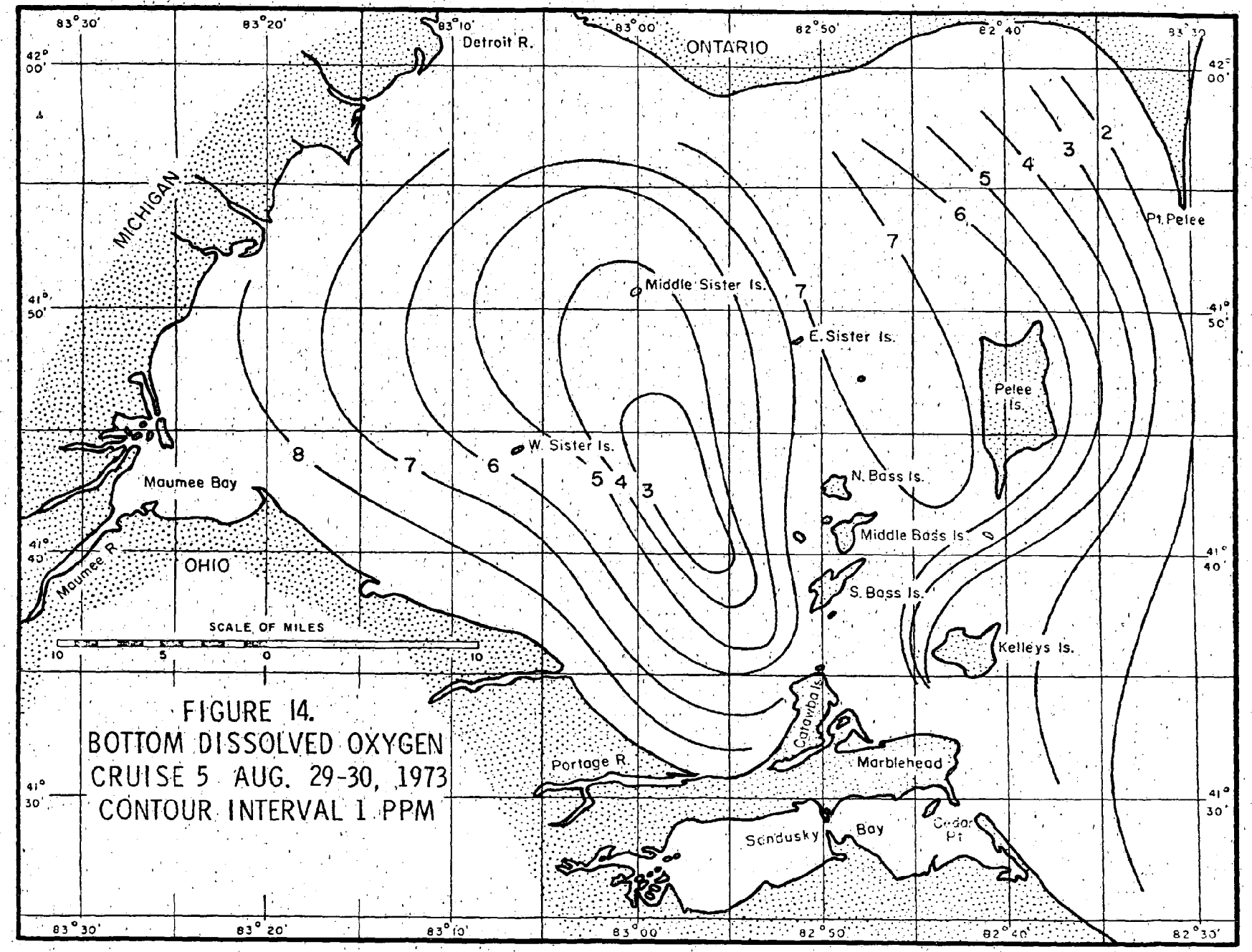


FIGURE 14.
BOTTOM DISSOLVED OXYGEN
CRUISE 5 AUG. 29-30, 1973
CONTOUR INTERVAL 1 PPM

The total phosphorus in the bottom waters for early May and early June 1974 showed similar patterns to those found for the surface waters, but the concentrations were approximately 10 ppb higher near the bottom. In mid-August when stratification resulted in the depletion of dissolved oxygen in the thin hypolimnion of the western part of the central basin a considerable increase in the total phosphorus was observed. In early September when the anoxic hypolimnion reached its maximum extent, the total phosphorus levels near the bottom were as high as 5-fold greater than those on the surface. The influence of both the phosphorus-rich Maumee River and the relative less phosphorus-laden Detroit River mid-channel on the bottom waters of the western basin was still apparent at this time. In late October the complete mixing of the lake lowered the total phosphorus in the bottom water except for a small area northwest of Cleveland. In general, the bottom concentrations in the western basin had experienced a decline and those in the central basin an increase during the period of the 1974 survey (April-October). Concentrations and quantities of total phosphorus in the western and central basins of Lake Erie were determined during six cruises in 1975 (Figures 15 and 16). Concentrations in both basins were noticeably higher in 1975 when compared with 1974 measurements.

Soluble reactive phosphorus. In late April and early May 1974 the soluble reactive phosphorus (SRP) in the surface water of the western basin ranged from 10-40 ppb, whereas all of the central basin surface water was less than 10 ppb and most of it less than 1 ppb. By early August phytoplankton growth had lowered this concentration to less than 5 ppb over most of the western basin except near the mouth of the Maumee River where levels over 15 ppb were detected. Concentrations remained less than 1 ppb over most of the central basin. In early September the southern half of the western basin again increased in soluble reactive phosphorus which extended eastward into the southwestern portion of the central basin. The influence of the Maumee and Detroit Rivers was again well illustrated. Most of the central basin remained at less than 1 ppb. In late October, following overturn, the surface concentrations in the western basin were dramatically decreased, whereas most of the central basin, particularly the Ohio side, increased to 1-5 ppb.

Bottom soluble reactive phosphorus concentrations in late April and early May were essentially the same as those found near the surface except that bottom levels near the mouth of the Maumee River were as high as 80 ppb. However, by mid-August the depressed oxygen levels in the thin hypolimnion in the western central basin had

FIGURE 15.
TOTAL PHOSPHORUS CONCENTRATION IN LAKE ERIE
1973 - 1975

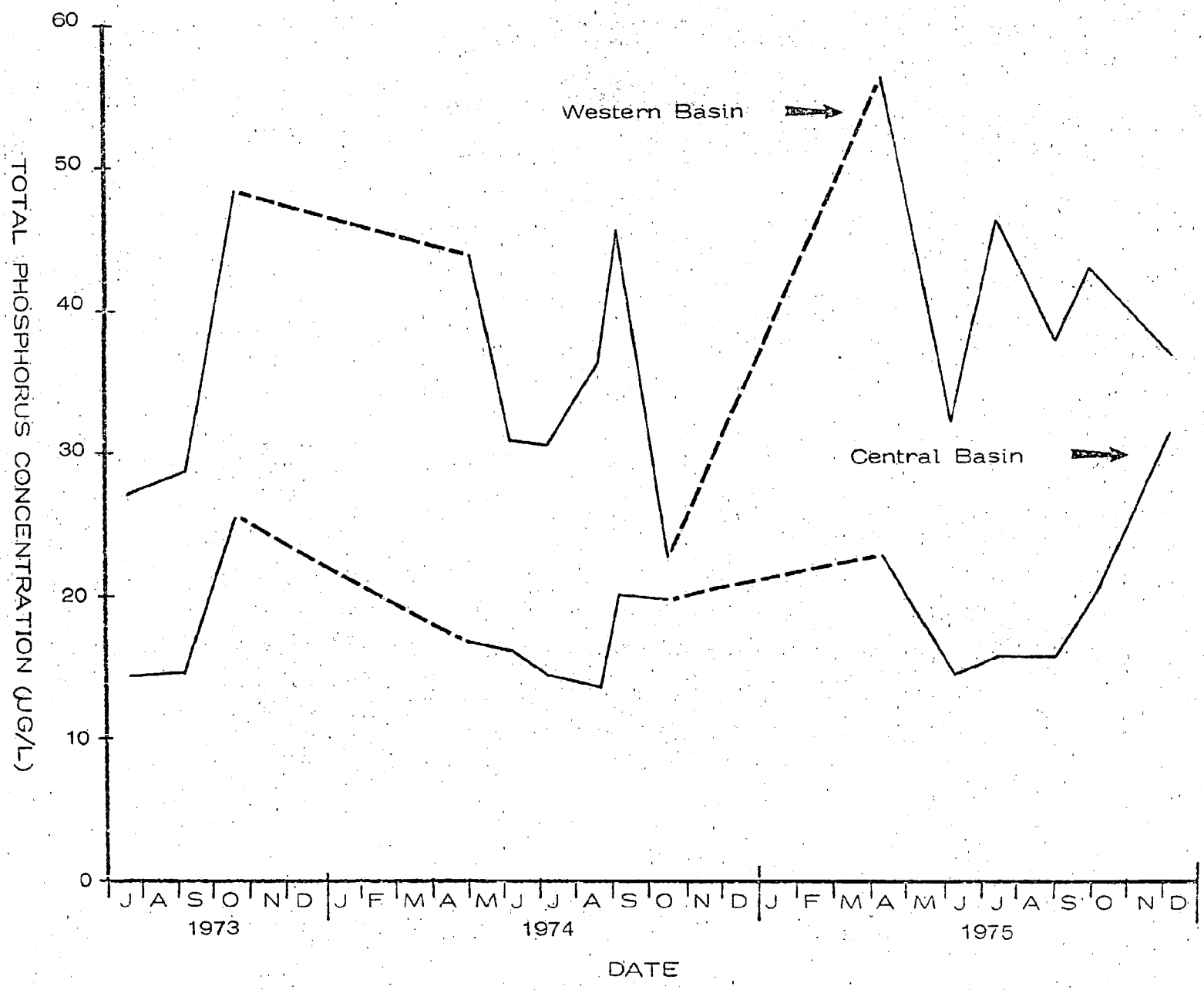
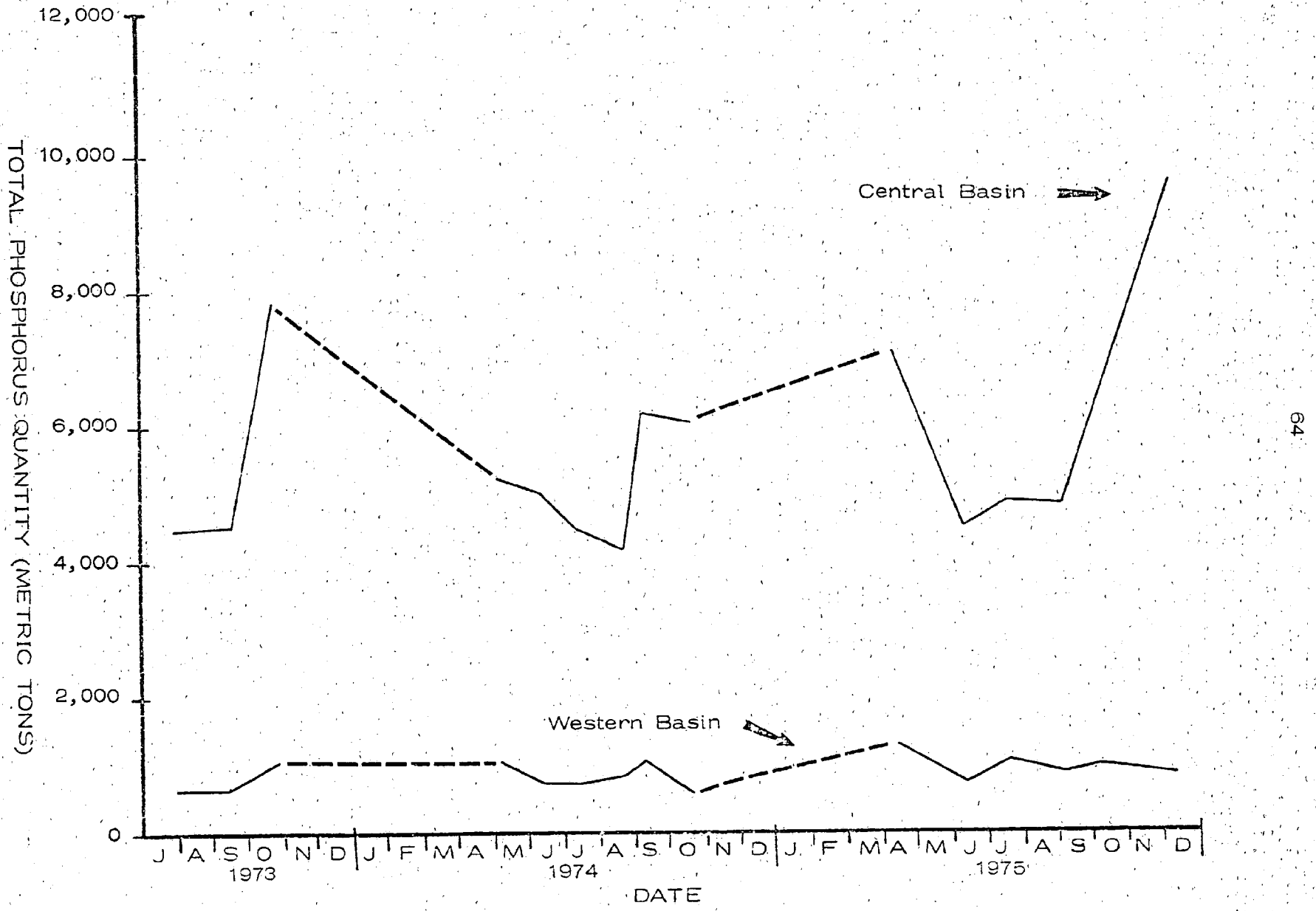


FIGURE 16.
TOTAL PHOSPHORUS QUANTITY IN LAKE ERIE
1973 - 1975



resulted in the regeneration of phosphorus from the bottom sediment with concentrations as high as 25 ppb. The process continued to spread throughout the central basin as more and more of the hypolimnion became anoxic. In early September phosphorus was being regenerated at a rate to produce concentrations from 10-50 ppb in most of the hypolimnion. Following overturn the bottom concentrations in the central basin fell sharply to 1-5 ppb, but a significant net increase had resulted over a six month period.

Trends in the 1974-1975 concentrations and quantities of soluble reactive phosphorus in the central and western basins of Lake Erie are depicted on Figures 17 and 18. Table 16 shows ten year trends for total and soluble reactive phosphorus and three forms nitrogen in all three basins of Lake Erie. Both TP and SRP indicate improvements in all three basins with the greatest reduction in the western and least in the eastern basin. With decreased loading from the Detroit River this type of cleansing pattern would be expected. However, data from the period 1970 (Burns and Ross, 1972) to 1975 show no significant change in the open lake concentration. Similar methodologies and statistical treatments have been used during this latter period, where the 1963-1965 studies utilized different techniques. The central and western basins of Lake Erie appear to have stabilized at a mean annual load of approximately 6000 metric tons of phosphorus.

Chlorophyll. Chlorophyll, green plant pigments essential to photosynthesis, can be used as an indicator of the relative algal biomass in an aquatic system. An analysis of chlorophyll concentrations over a period of years may show long term trends in algal populations.

In 1967 the Federal Water Pollution Control Administration (1968) conducted 3 cruises on Lake Erie during which chlorophyll *a* and *b* determinations were made on water samples from 30 stations. The mean annual concentration for the western, central and eastern basins was 23, 9 and 6 µg/l respectively.

Glooschenko *et al.* (1974) reported on chlorophyll determination from 10 Lake Erie cruises during the period April to December 1970. They found the highest mean chlorophyll *a* values (11 µg/l) occurred in the mid-western basin, with a second maximum (6 µg/l) in the eastern basin north of Erie, Pennsylvania. The southern shore of the central basin was also characterized by high values, particularly east of Cleveland Ohio. The lowest yearly means were found in the eastern portion of the central basin and most of the eastern basin (3 µg/l).

FIGURE 17.

SOLUBLE REACTIVE PHOSPHORUS CONCENTRATIONS IN LAKE ERIE
1974 - 1975

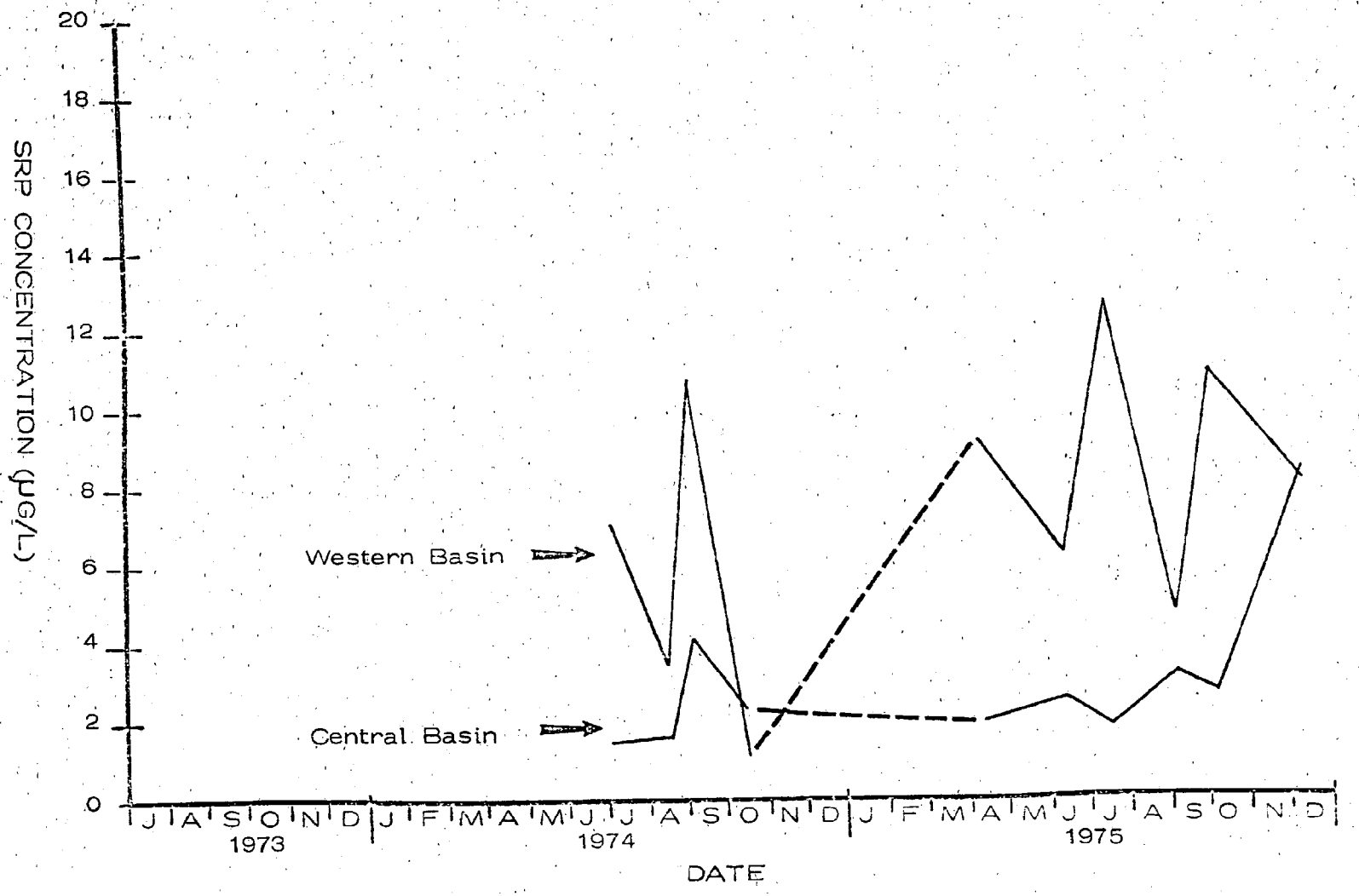


FIGURE 18.
SOLUBLE REACTIVE PHOSPHORUS QUANTITY IN LAKE ERIE
1974 - 1975

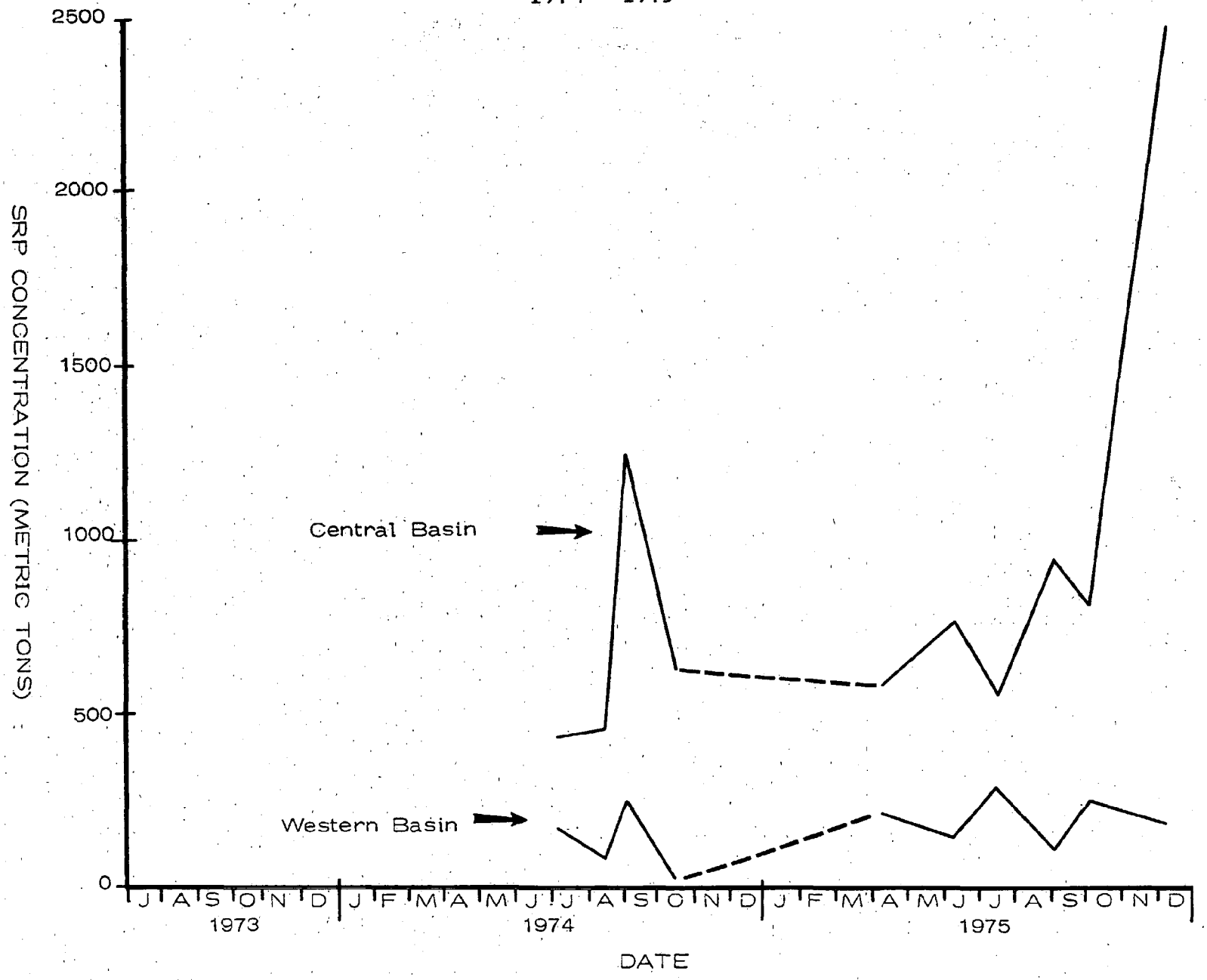


TABLE 16

TEN-YEAR COMPARISON OF MEAN WATER QUALITY IN LAKE ERIE

PARAMETER	PERIOD OF OBSERVATION				PERCENT OF 1963-64 QUANTITY PRESENT IN 1973-74
	1963 - 1965		1973 - 1974		
	mg/l	tons (M)	mg/l	tons (M)	
Total Phosphorus					
Western Basin	0 160	3,800	0.035	839	22.1%
Central Basin	0.065	20,000	0.017	5,207	26.0
Eastern Basin	0.060	9,100	0.030	4,554	50.0
Soluble Phosphorus					
Western Basin	0.032	700	0.005	130	18.6
Central Basin	0.010	3,000	0.002	706	23.5
Eastern Basin	0.010	1,500	0.005	759	50.6
Total Inorganic Nitrogen					
Western Basin	0.350	8,400	0.298	7,090	84.4
Central Basin	0.176	53,000	0.157	48,663	91.8
Eastern Basin	0.176	26,700	0.158	23,984	89.8
Nitrate-Nitrite Nitrogen					
Western Basin	0.124	2,900	0.274	6,532	225.2
Central Basin	0.090	27,000	0.143	44,416	164.5
Eastern Basin	0.090	13,600	0.084	12,751	93.8
Ammonia Nitrogen					
Western Basin	0.159	3,800	0.024	558	14.7
Central Basin	0.086	25,700	0.014	4,247	16.5
Eastern Basin	0.086	13,000	0.074	11,233	86.4

Data Sources:

1963-64 - Federal Water Pollution Control Administration (FWPCA, 1968a).
1973-74 - Center for Lake Erie Area Research
Great Lakes Laboratory

Investigations by the Center for Lake Erie Area Research and the Great Lakes Laboratory showed a distinct gradient in chlorophyll a concentrations from the western basin to the eastern basin in 1973, similar to that found by Glooschenko et al. (1974). Basin values for the period July to October are given in Table 17. The central basin has been divided into a western and eastern half to demonstrate the marked gradient across this basin. The western half showed a definite transition zone due to the influence of large algal populations in the western basin, whereas the eastern half was similar to the eastern basin and contained the lowest chlorophyll a concentration in the lake during the summer. Figure 19 presents a graph of chlorophyll a concentrations in the lake during the period June 1973 to December 1975 which demonstrates the relationship of the basins and the seasonal variations which occur each year in response to algal populations.

Trends in the chlorophyll concentration in Lake Erie surface water is shown in Figure 20. Although the 1967 data contain both chlorophyll a and b, a definite downward trend in the western basin biomass is indicated when compared with the other two basins. This trend is consistent with other chemical and biological parameters which also show a major improvement in the western basin and lesser amounts of recovery for the other two basins. The improvement appears to be related to the reduction in nutrient loading from the Detroit River and other tributaries which enter the western basin. Therefore, the nearly three-year flushing rate of Lake Erie would be expected to slow the response to reduced nutrients in the down stream basins. If the present trend continues, increased recovery should be observed in both the central and western basins.

TABLE 17

AVERAGE SURFACE CHLOROPHYLL a IN LAKE ERIE - 1973
UG/L

Date	Western Basin	Central Basin		Eastern Basin
		West half	East half	
Mid-July	9.36	4.59	1.90	3.28
August-September	15.08	4.92	2.30	3.85
Mid-October	11.38	8.95	7.77	6.12
Annual Mean	11.94	6.15	3.99	4.42
Annual Ratio	2.70	1.46	0.90	1.00

FIGURE 19.
VOLUME WEIGHTED CONCENTRATION (µG/L) OF
CORRECTED CHLOROPHYLL a IN LAKE ERIE 1973 - 1975

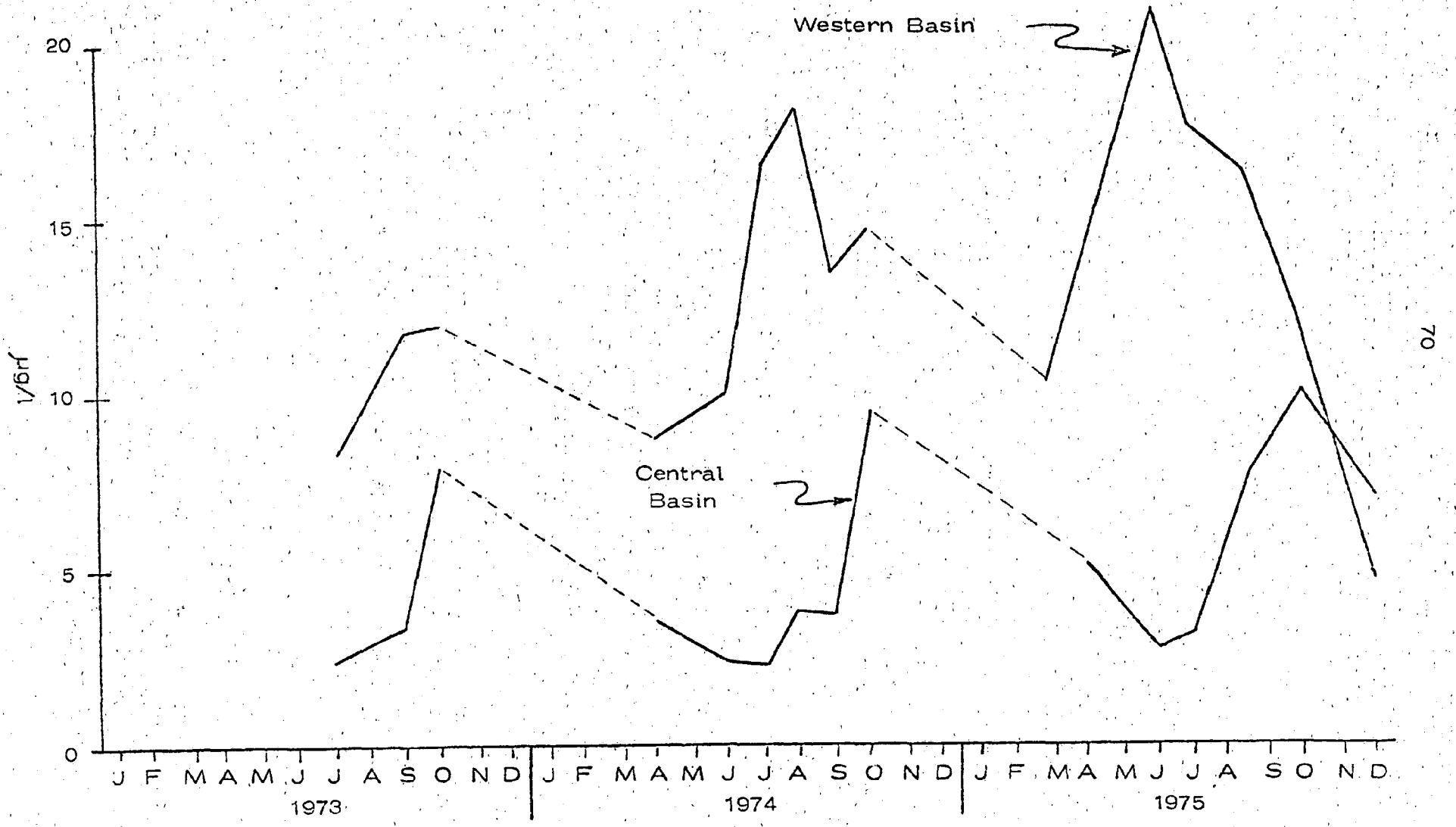
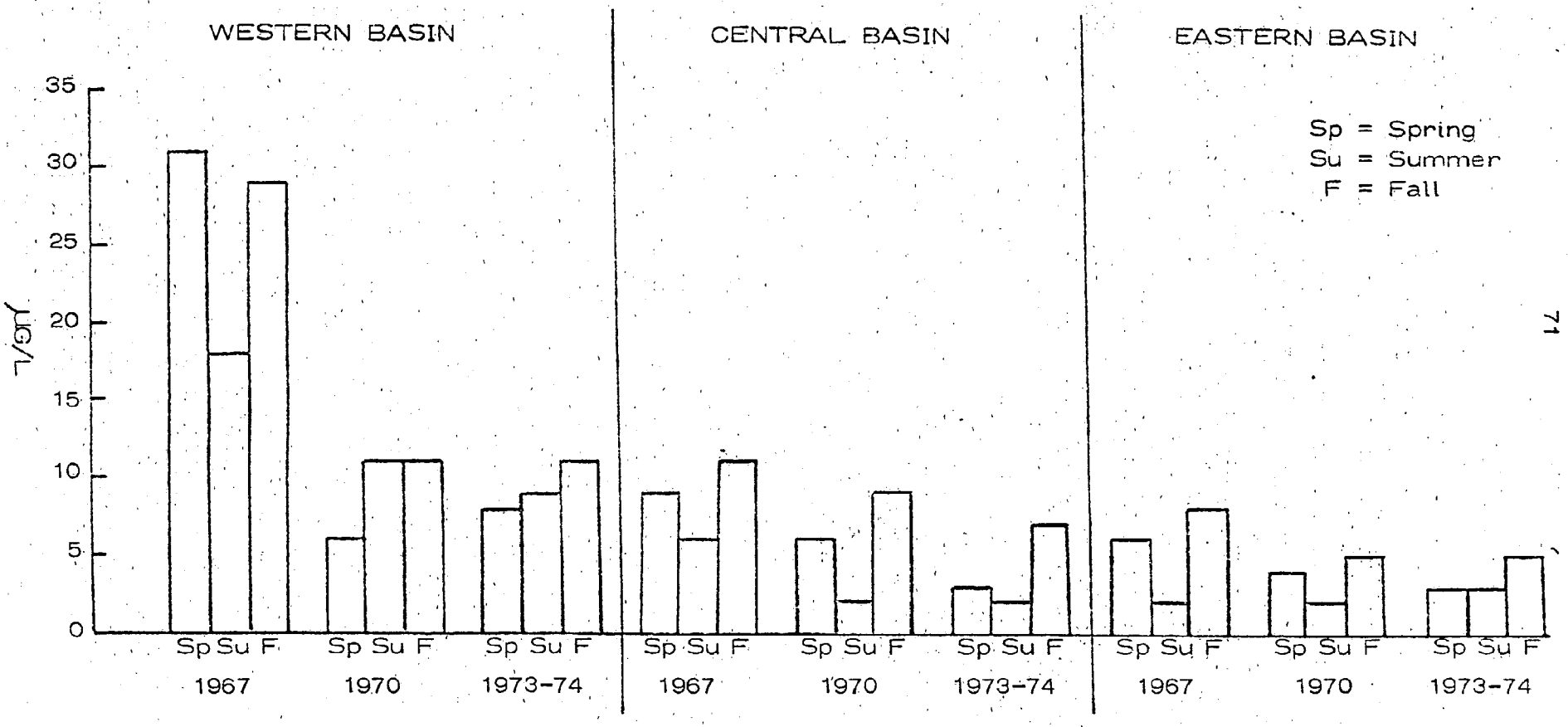


FIGURE 20.

TRENDS IN LAKE ERIE SURFACE WATER CHLORCPHYLL
1967 - 1974



Data Sources:

1967: Federal Water Pollution Control Admin. (1968a & b) - Chlorophyll reported as corrected a & b

1970: Canada Centre for Inland Waters - Chlorophyll reported as corrected a

1973-74: Center for Lake Erie Area Research and Great Lakes Laboratory - Chlorophyll reported as corrected a

During the period 1973-1975 chlorophyll a concentrations in the western and central basins of Lake Erie have increased (Figure 19). The peak summer concentration (volume weighted) in the western basin has risen from approximately 12 µg/l in 1973 to 21 µg/l in 1975. In the central basin the peak concentration occurs in the fall. A similar increase was observed in this peak, from 8 µg/l in 1973 to 10 µg/l in 1975. Intermediate concentrations were found in both basins in 1974. Volume weighted quantities of chlorophyll a also increased in the western and central basins from 1973 to 1975 (Figure 21). The central basin quantities increased significantly between 1974 and 1975 but the rise in the western basin was less pronounced.

Table 18 shows the ratio of chlorophyll a concentrations in the western and central basins. The western basin concentration during spring and summer is normally 2 to 10 times greater than the eastern part of the central basin. In fall there is less difference in the basins. The ratios between 1973 and 1975 reveal a trend toward a decreasing dominance of concentrations in the western basin, particularly in the fall. This is probably the result of a decrease in nutrient loads to the western basin via the Detroit River coupled with the regenerated nutrient added to the central basin after fall overturn.

FIGURE 21.

VOLUME WEIGHTED QUANTITY (METRIC TONS) OF CORRECTED CHLOROPHYLL a IN LAKE ERIE 1973 - 1975

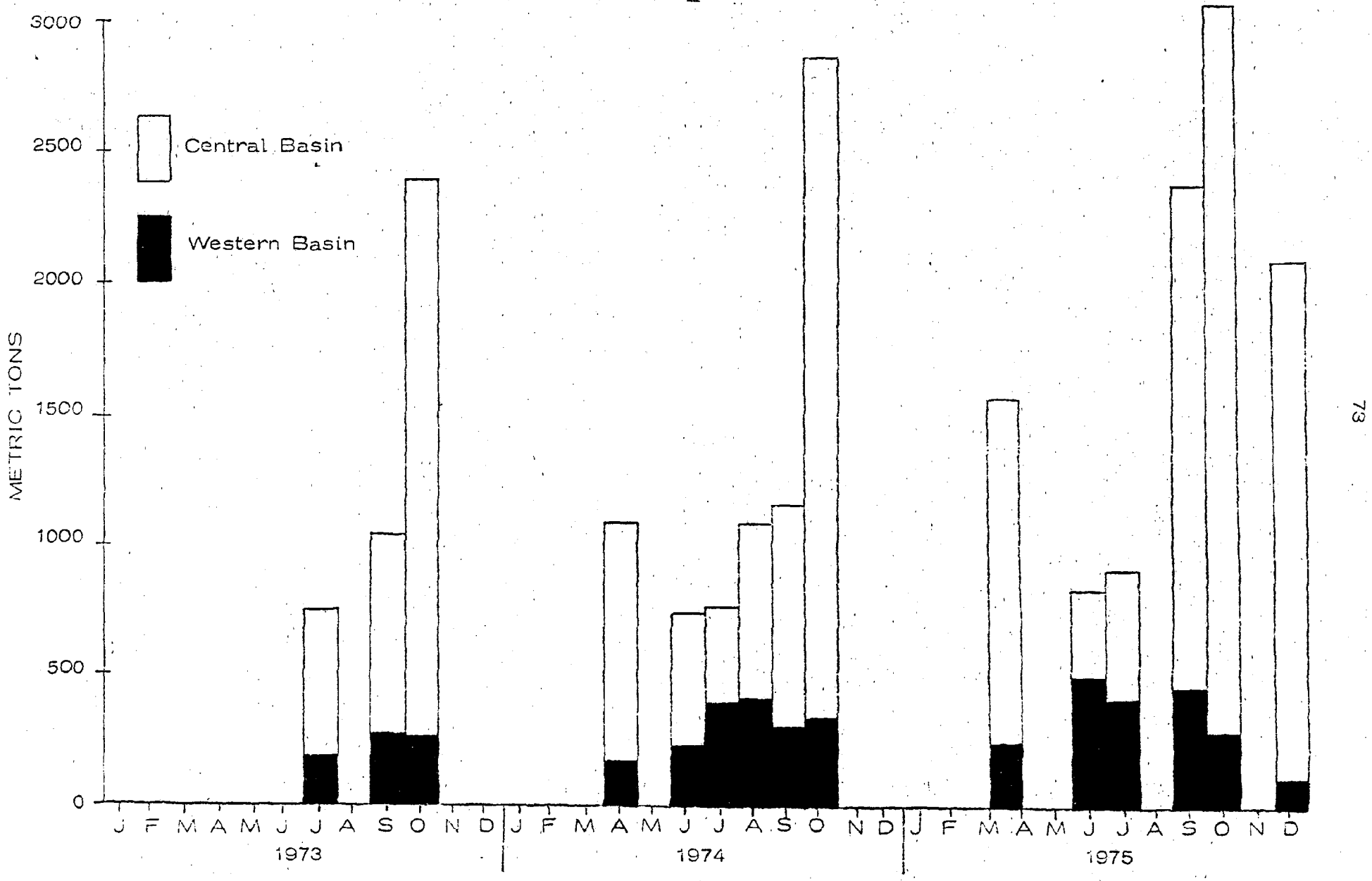


TABLE 18.

RATIO OF CHLOROPHYLL a CONCENTRATION IN WESTERN AND CENTRAL BASINS OF LAKE ERIE 1973 - 1975

DATE	WESTERN BASIN	CENTRAL BASIN	
		West Half	East Half
April			
1974	2.91	1.44	1.00
1975	2.33	1.41	1.00
June			
1974	3.95	0.80	1.00
1975	8.78	1.37	1.00
July			
1973	4.77	2.05	1.00
1974	9.82	2.23	1.00
1975	7.45	1.90	1.00
August			
1974	6.21	2.09	1.00
September			
1973	4.95	2.20	1.00
1974	4.75	1.92	1.00
1975	2.57	1.62	1.00
October			
1973	1.56	1.08	1.00
1974	1.89	1.62	1.00
1975	1.22	0.98	1.00
December			
1975	0.70	1.13	1.00

CLIMATOLOGY OF THE LAKE ERIE ISLAND REGION

Lake Erie Basin

The climate of the Lake Erie basin is classified as temperate humid-continental. The location of the Great Lakes between the source regions of contrasting polar and tropical air masses gives the region rapidly changing and complex weather patterns. The average annual air temperature for Lake Erie land stations ranges between 47°F and 51°F. The highest average monthly temperature occurs in July (70°F to 75°F) and the lowest in January (24°F to 28°F). Approximate extremes are -20°F and 100°F.

The average annual precipitation in the Lake Erie basin is about 35 inches and ranges between 32 and 38 inches. The total land area which drains into Lake Erie, excluding that above the Detroit River, is only about three times the area of the water surface of the lake. The large expanse of water affords a great opportunity for evaporation, and the amount of water lost in this manner is nearly equivalent to the average precipitation over the lake. During dry periods more water may be evaporated from the lake than flows into it from all of its tributaries. Under these conditions Lake Erie delivers into the Niagara River a smaller quantity of water than it receives from the Detroit River.

Of the total possible hours of sunshine for the Lake Erie basin, the amount is greatest in midsummer (70 %) and least in winter (40 %), even though 70% of the precipitation occurs between March and August. The proximity of the cool lake water and the large amount of moisture put into the air by evaporation cause frequent periods of fog.

Lake Erie, because of its comparative shallowness, its northeast-southwest orientation, and strong winds from these directions, can raise a dangerous sea in a short period of time. Prevailing winds (most frequent direction) are from the southwest (Figure 22). The strongest winds come from the westerly quadrants with a secondary maximum from the northeast. The average monthly wind speed ranges from about 8 mph to 18 mph, with the highest average occurring during the winter months and in the eastern part of the lake.

The predominant southwest and west winds over Lake Erie are explained by Powers, et al.(1960) in terms of "streamlines" of air movements in the Great Lakes region. Figure 23 illustrates the streamlines which influence wind directions in the island region. Masses of air moving from the west are abruptly shifted toward the northeast producing a southwest wind.

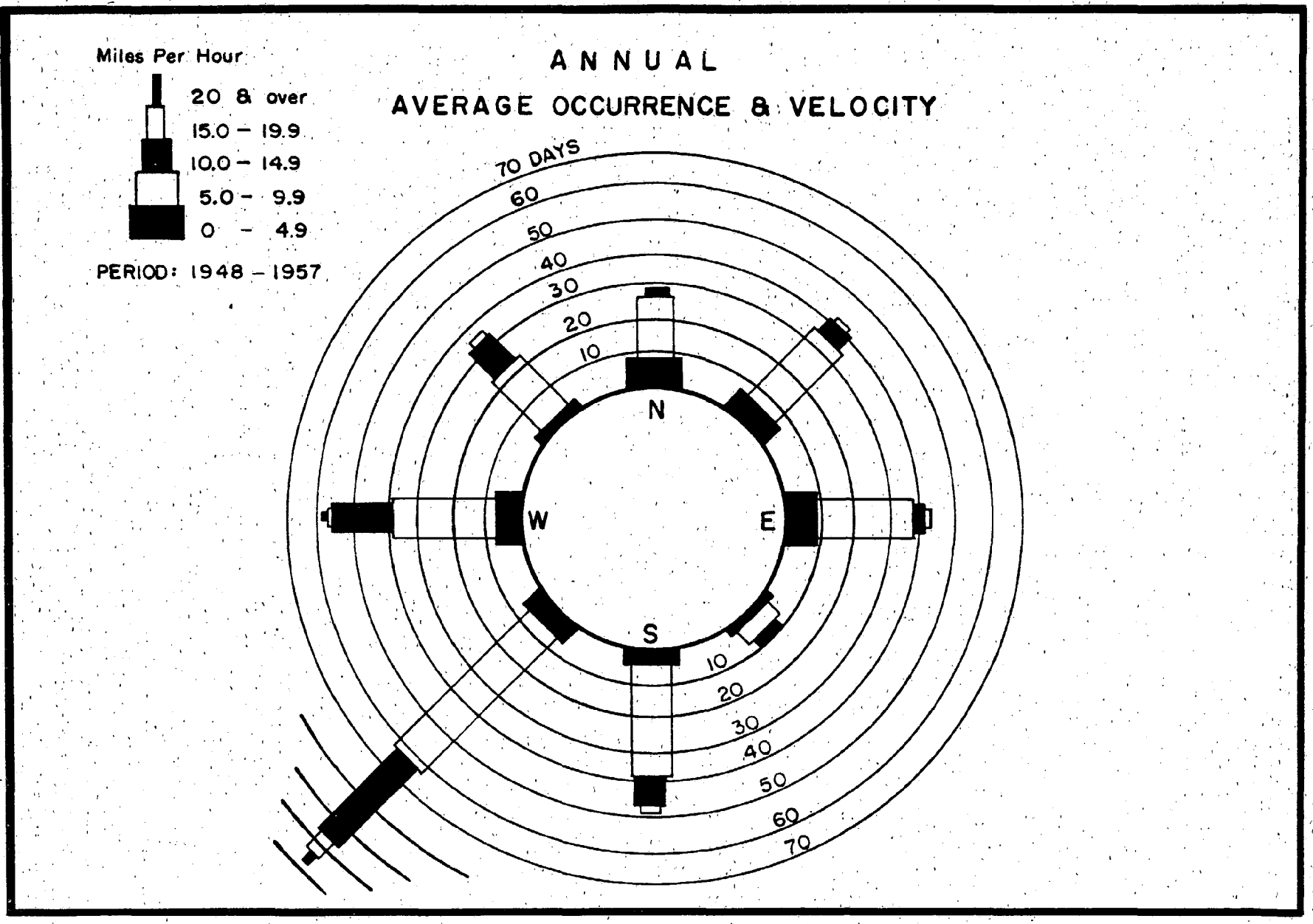


FIGURE 22. AVERAGE ANNUAL WINDS AT SANDUSKY, OHIO (after Verber, 1955).

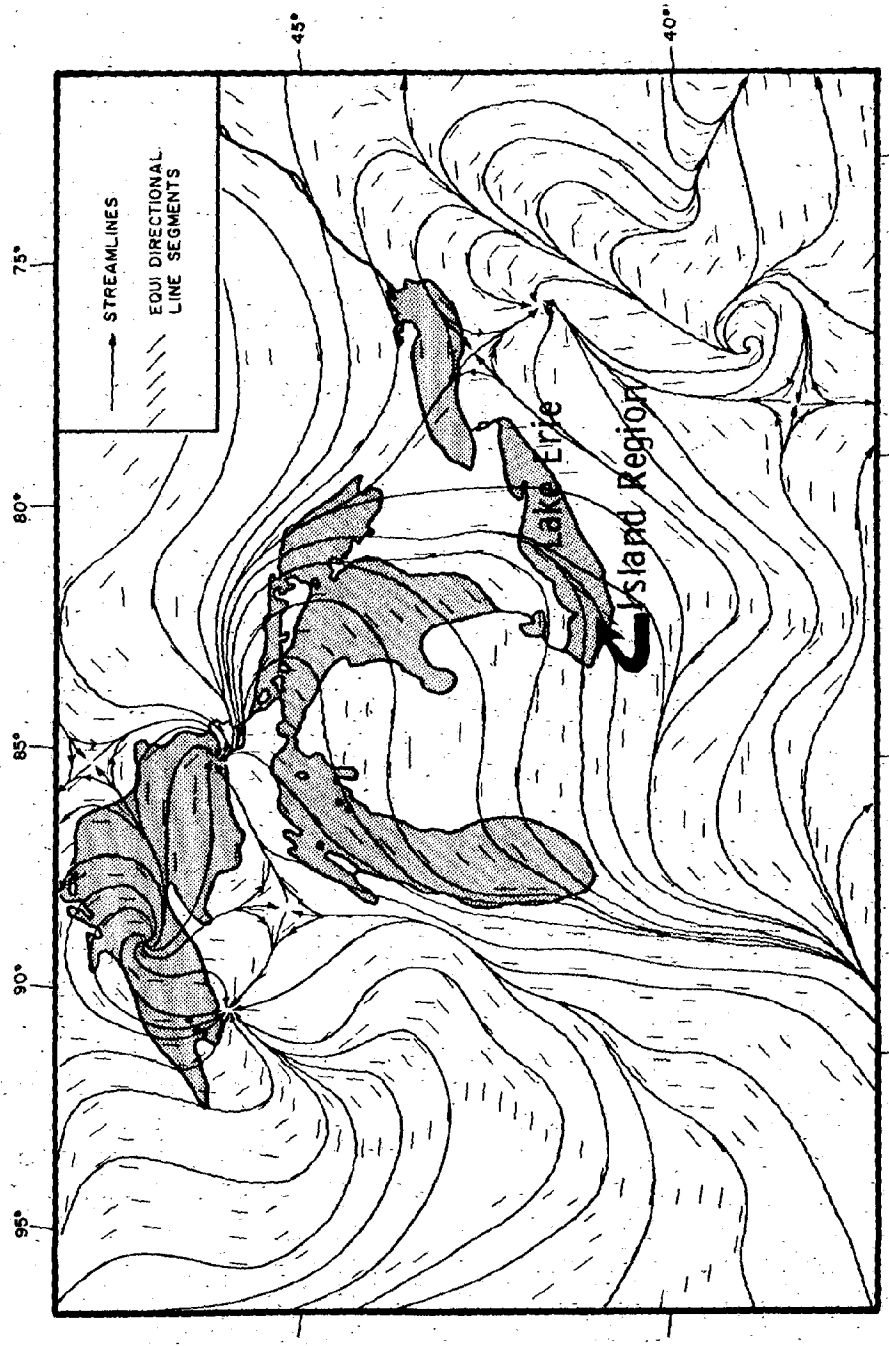


FIGURE 23. STREAMLINES OF AIR MOVEMENTS IN THE GREAT LAKES REGION (Powers, et al., 1960).

Lake Erie Islands

This section on the climate of the Lake Erie islands was prepared by Dr. Ronald L. Stuckey of The Ohio State University. This information was compiled as part of a study of the flora of the island region.

The Lake Erie islands have a climatic variation which is unlike that of the mainland region around the lake. The annual mean temperature range is greater, the daily range between the maximum and minimum temperatures is smaller, the precipitation is less, wind velocities are greater, and the frost-free seasons are longer. The western basin of Lake Erie, the warmest large body of water in the Great Lakes, has a pronounced effect upon the climate of the islands compared with the climate of nearby mainland stations (Verber, 1955).

Temperature. Based on the data for 1950, the mean monthly temperature range between the maximum and minimum temperatures was 13.7°F. for Put-in-Bay compared with 21.5°F for Bucyrus, within 50 miles of the lake (Table 19). The great thermal stability of the water acts as a damper between sudden heating or cooling. The mean temperatures for January, the coldest month, and the mean temperature for July, the warmest month, are given for the five stations from the islands and the mainland (Table 19). Put-in-Bay has the lowest mean temperature in January and the highest mean temperature for July, accounted for by the frozen lake and the greater solar radiation at Put-in-Bay compared to other stations at the same latitude.

Precipitation. The annual precipitation is noticeably less on the islands than at the other adjacent mainland stations. The variation in precipitation for three of the islands and four mainland stations compared, shows a progressive decrease from Bucyrus to South Bass Island (Table 20). Alexander (1924) reported that North Bass Island, for the years recorded, had the lowest annual amount of precipitation, 27.82 inches compared to 30.04 for South Bass. The decrease in summer rainfall is due to the deflection of thunderstorms around the lake rather than passing over the islands. The storms that do cross the lake do not form as much rain because higher air temperatures over land can maintain the energy needed to develop thunderstorms whereas cooler temperatures over the lake do not provide enough energy. Because of low rainfall, high solar radiation, and continued movement of the air, evaporation actually exceeds precipitation in June, July, and August. The evaporation/precipitation ratio affects the seasonal aspect of the flora in that the dryness of the late summer and fall is reflected by the paucity of terrestrial herbaceous vegatation.

TABLE 19

CLIMATIC VARIATIONS WITHIN 50 MILES OF LAKE ERIE

Station	Average Monthly Temperature Range	Mean Temperature		Distance from Lake Erie	Mean Precipatation	Frost free season
		January	July			
Put-in-Bay	13.7 °F	26.8 °F	74.8 °F	0 miles	28.99 inches	205 days
Sandusky	15.9	27.0	74.0	1	32.05	194
Toledo	18.8	26.9	74.0	15	32.11	185
Tiffin	19.5	27.9	73.8	30	36.99	162
Bucyrus	21.5	27.7	73.6	50	38.39	154

Sources: U.S. Dept. Agr. (1941), U.S. Weather Bureau (1950) and Verber (1955).

TABLE 20

AVERAGE MONTHLY PRECIPITATION AT PUT-IN-BAY AND SURROUNDING AREAS

Station	Precipatation in Inches												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
North Bass	1.87	1.29	2.22	2.56	2.44	2.716	2.47	2.24	2.79	2.05	2.09	1.97	26.70
Put-in-Bay	1.96	1.51	2.37	3.00	3.05	3.00	2.44	2.78	2.71	2.20	1.99	1.98	28.99
Kelleys Island	1.82	1.74	2.62	2.80	3.20	3.45	3.33	2.47	3.24	2.28	2.59	2.20	31.74
Sandusky	2.45	1.81	2.80	2.73	2.93	3.42	3.32	3.05	3.08	2.37	1.95	2.13	32.05
Toledo	2.39	1.89	2.86	3.04	3.11	3.30	2.82	2.98	3.08	2.32	2.02	2.39	32.11
Tiffin	3.00	2.25	3.44	3.35	3.62	3.69	3.74	2.99	3.30	2.70	2.30	2.61	36.99
Bucyrus	3.16	2.26	3.36	3.28	3.59	4.04	4.12	3.16	3.29	2.94	2.55	2.64	38.39

Sources: Alexander (1924), U.S. Dept. Agr. (1941) and Verber (1955).

Growing season. Although nearly the most northern portion of the state, South Bass and the other islands have the longest frost-free period of any area in the state of Ohio. South Bass Island has an average frost free period of 205 days, while Bucyrus has an average of 154 days (Table 19). North Bass has a frost-free period of 206 days (Verber, 1955). The high heat capacity of the lake (Figure 24) prolongs the summer temperature far into fall while the small range of temperature between the maximum and the minimum daily temperature permits a long spring (Table 21). The long frost-free period, however, does not indicate a long growing season. The spring temperatures are retarded, and the threshold temperature, or temperature denoting the beginning of the blooming period of the flora, in the spring, occurs much later on the islands than on the mainland. This retardation is reflected by the average date of the last killing frost, which is around April 15 for the islands, contrasted with May 20 for the interior of Ashtabula County, nearly in the same latitude, and with April 30 as far south as Columbus. Similarily, the average date for the first killing frost in the fall is around October 30 for the islands, contrasted with September 30 for Ashtabula County, October 15 for Columbus, and October 20 for Cincinnati. Thus, the average length of the growing season for the islands is over 192 days.

Microclimates. Microclimatic conditions on South Bass Island were determined by sampling at 37 different temperature stations from July 1944 to August 1948 (Verber, 1955). The following seven microclimates were apparent: (1) high and (2) low leeward shore stations, (3) high and (4) low windward shores, (5) high and (6) low inland stations, and (7) wooded areas. Daily temperatures showed the most significant changes. In winter, the variations between the low frost pockets and the high lee shore stations were as great as 18°F. During the summer the lee shore stations, especially the East Point area, were the warmest parts of the island. The frost free season for the island varied in 1945 from 187 to 251 days for the various selected microclimatic habitats. This range on the island, however, is greater than that which normally occurs between South Bass Island and Bucyrus.

TABLE 21

AVERAGE MONTHLY AIR AND WATER TEMPERATURES AT PUT-IN-BAY, SOUTH BASS ISLAND, 1966 - 1971 - 1976.

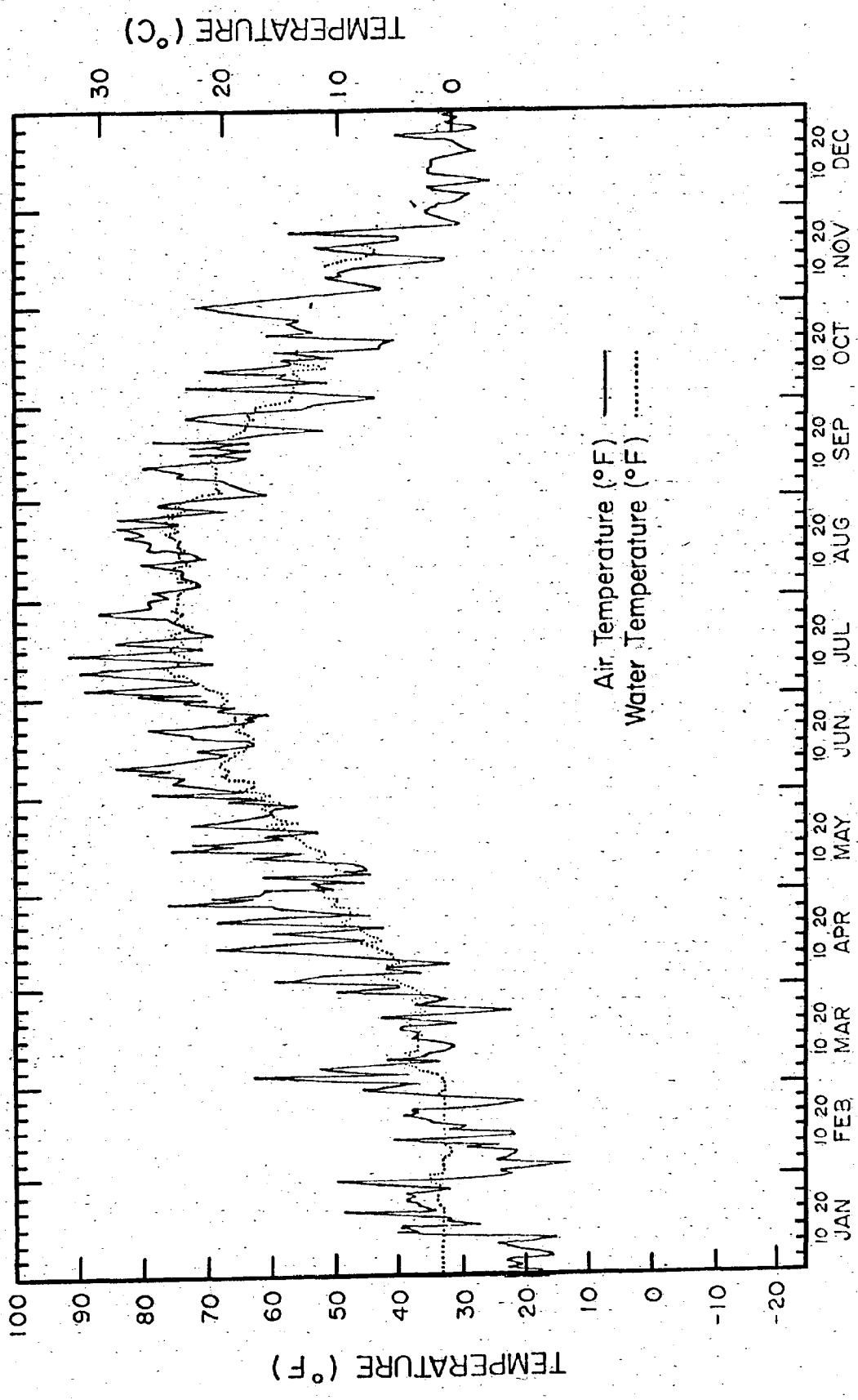
Year	Month	Average Maximum Air Temp.(°F) [1]	Average Minimum Air Temp.(°F) [1]	Extreme Maximum Air Temp.(°F) [1]	Extreme Minimum Air Temp.(°F) [1]	Precipitation (to nearest .01") [1]	Water Temperature (°F) [2]
1966	January	30.2	16.9	56	-1	0.64	32.48
	February	31.4	20.2	56	5	1.15	33.64
	March	46.9	29.2	68	19	2.10	37.29
	April	52.7	37.3	73	30	4.04	45.87
	May	58.5	44.1	86	32	2.45	55.81
	June	80.6	60.7	94	42	4.89	69.33
	July	86.0	66.0	96	41	7.79	76.81
	August	80.16	62.42	87	56	4.05	74.13
	September	73.6	56.3	89	45	1.65	67.17
	October	62.0	44.7	77	34	1.04	55.16
	November	51.0	35.9	68	24	5.00	43.93
	December	37.6	25.8	63	11	4.90	35.94
1971	January	30.1	15.03	53	-3	0.79	33.00
	February	35.57	21.5	53	-5	3.68	33.21
	March	41.3	26.5	66	16	0.99	34.80
	April	55.6	35.4	69	28	0.94	44.23
	May	67.74	47.87	85	37	3.25	55.73
	June	82.2	61.37	97	52	2.17	69.77
	July	83.0	63.6	90	56	3.07	75.50
	August	78.9	62.4	90	50	0.98	73.73
	September	76.9	62.6	92	50	1.81	71.00
	October	68.0	55.0	84	45	1.74	63.30
	November	41.2	36.3	69	24	1.18	49.10
	December	45.0	31.1	59	21	3.39	38.57
1976	January	29.3	16.2	47	0	2.66	34.10
	February	44.6	25.2	62	-1	2.93	33.97
	March	53.0	34.0	74	17	3.61	39.81
	April	61.0	41.8	85	29	1.97	49.23
	May	67.5	49.2	77	38	3.79	56.61
	June	-	62.5	90	53	2.58	71.53
	July	84.7	65.2	98	59	1.65	74.45
	August	80.3	63.1	89	55	1.67	71.48
	September	74.0	57.0	88	46	4.65	67.10
	October	N.A.	N.A.	N.A.	N.A.	N.A.	54.65
	November	N.A.	N.A.	N.A.	N.A.	N.A.	40.10
	December	N.A.	N.A.	N.A.	N.A.	N.A.	33.32

[1] Perry's Monument

[2] Put-in-Bay Fish Hatchery

FIGURE 24.

AIR AND WATER TEMPERATURES AT PUT-IN-BAY, OHIO, 1974



SHORE EROSION IN THE LAKE ERIE ISLAND REGION

The record high water levels in Lake Erie during the past five years have contributed greatly to increased erosion of the shores. The narrow beaches fronting the shore bluffs of the islands have been submerged exposing the bluffs to direct wave attack and erosion by alongshore currents. Severe storms have resulted in profound changes in shoreline configuration and disruption of man's use of the coastal zone.

Water Levels

Water level changes on Lake Erie are of two principal types: (1) long period and (2) short period oscillations. Long period fluctuations are related to volumetric changes of the lake, caused principally by variations in precipitation, evaporation and runoff. These changes include both seasonal fluctuations and those occurring over a period of several years. Short period fluctuations are due to a tilting of the lake surface by wind or atmospheric pressure differentials. Wind tides, seiches and harbor surges, which have periods from a few seconds to several days are examples of short term oscillations. Sun and lunar tides are negligible, resulting in maximum fluctuations of 0.11 feet (Verber, 1960).

Water levels at the ends of Lake Erie (Toledo and Buffalo) have a much greater fluctuation than near the center. Tilting of the lake surface is analogous to the up and down movement of the ends of a teeter-totter while the center is stable. High water levels coupled with northeast storms have produced a maximum rise in level of 9 feet above Low Water Datum at Toledo. Conversely, low water and southwest winds have lowered the level to 7 feet below Datum, a range of 16 feet. Under the influence of wind, currents tend to bank up water on the windward shore. This forced movement of the lake surface is known as wind tide and the amount of rise produced is the wind setup. The resulting free oscillation of the lake surface caused by the inequality of water level is called a seiche. Such free oscillations are nearly continuous in the islands region and most often have a period of 12 hours and amplitude of less than 2 feet (maximum amplitude: 5-6 feet).

The major seiches on Lake Erie are essentially parallel to the longitudinal axis of the lake. Seiches along this axis have a period of

approximately 12-14 hours. Seiche periods as recorded for three years at a water level gauge at Put-in-Bay on South Bass Island indicated that longitudinal seiches were in operation about 44% of the year. Surface winds from the southwest or northeast are likely to produce such seiches along the long axis of the lake. Wind records from Sandusky, Ohio are in agreement with the frequency of seiche periods; surface winds from these directions occur approximately 150 days (42%) of the year.

Wave Action

Wave action follows wind action very closely on Lake Erie because of the shallowness of the lake. Swells, however, often continue into the next day after a storm subsides. The depth of the water and the direction, velocity, duration, and open water fetch of the wind collectively determine the characteristics of waves at a given location. The U.S. Army Corps of Engineers (1953) estimates that off Marblehead Peninsula, with a fetch of 150 miles and a wind velocity of 30 miles per hour, the maximum wave for Lake Erie is developed in 20 hours. Given these conditions a wave 12.5 feet high with a 6.5 second period can be developed. Waves of this height break offshore, but reformed waves up to 3.5 feet in height can reach the shoreline of the islands.

Alongshore Currents

As waves approach the shoreline the water level rises at the shore and the excess water escapes as alongshore (littoral) currents. These currents can be particularly rapid when waves approach the shore at angles other than perpendicular (up to 4 ft/sec) and result in the transport of beach materials as large as cobbles and boulders. The currents are important agents of erosion, transportation and deposition of sediments in the island region.

All of the islands are rockbound (or protected by a seawall in the case of Turtle Island) and are undergoing very slow erosion by scour from waves and currents. However, during the recent period of high water many large blocks of dolomite have fallen from the high cliffs of several of the islands. This problem has become particularly acute at the south point of South Bass Island in 1976

and necessitated the relocation of the U.S. Coast Guard navigation light tower which was in danger of falling into the lake. The highest incident of erosion appears to take place in the spring and fall. Ground water seeping into cracks and joints in the rocks freezes, expands and tends to split the rock from the cliffs, a process known as frost wedging. This process coupled with frequent and severe storms in the spring and fall has resulted in many offshore blocks of dolomite which ring the west shores of several of the islands.

The low eastern shores have experienced another problem during the high water period, flooding. Several homes and cottages have been destroyed or severely damaged during northeastern storms which have caused the lake to inundate the eastern shores. This problem has lessened in the past few years as the lake level has fallen to a nearly normal level.

Alongshore currents also produce excellent beaches. The best example in western Lake Erie is on one of the Canadian islands. Fish Point, a spit at the southern tip of Pelee Island, contains the largest deposit of sand in the island region. It is likely that the bulk of the sand has come from glacial moraine deposits of sand and gravel lying east and west of the island. Converging southerly currents along the east and west sides of the island have built the nearly two-mile-long spit.

In the north bay of Kelleys Island at the State Park some local accretion has formed a bayhead beach, the largest sand deposit in the Ohio islands. The sand and gravel is mainly derived from erosion of the low glacial till banks of the bay shore. Rattlesnake, Green and West Sister Islands have pebble bars extending eastward from their eastern shores. The bars were probably formed by strong eastward-moving currents along the north and south shores of the islands. Sand and gravel beaches occur in small pockets on Middle Bass and South Bass Islands. The beaches are thin and are either residual material from the underlying till or are deposits trapped between the bedrock headlands. Wave and current action is vigorous throughout the island region.

BIOTA OF THE LAKE ERIE ISLAND REGION

Vegetation

The vegetation of the islands in western Lake Erie has been the subject of many studies, the latest and most comprehensive by Stuckey and Duncan (1977) comprising a cataloging of all the vascular plants on the islands. Much of the material in this section is based on their findings. Several distinctive habitats exist on the islands, each having its own characteristic species composition. These habitats are the woodlots, quarries, open fields, vineyards, pond-marshes, and the constantly changing shoreline areas of wave-splashed cliffs, low shelf-like rocky shores, sandy beaches, and gravel beaches.

The islands are unique in possessing a combination of eastern, western, and southern species at the extreme edges of their total ranges. Many of these species occur in open, naturally disturbed sites along cliffs, sandy shores, and pond-marsh habitats, all of which occur on the Erie Islands. These habitats represent the environment present most extensively at the time of the retreat of the late Wisconsin glacier. Species on unglaciated lands to the west, east, and south migrated to the then newly glaciated soils. Being able to survive only under fluctuating conditions, these species have continued to populate these relic, ever changing areas on the islands. Four species in these habitats are the only species identified as being endemic varieties from the islands: Rubus corei (Core's blackberry), Rubus eriensis (Lake Erie blackberry), Rubus gordonii (Gordon's dewberry), and Polygonum pennsylvanicum var. eglandulosum (smartweed) (Stuckey and Duncan, 1977).

Woodlots. The original forests of the Lake Erie island area developed about 12,500 years ago with the retreat of the late Wisconsin glacier. The lake bottom was drained and became a dry forested region. The dominant woody species association was spruce, fir, hemlock, jack pine, birch, poplar, creeping juniper, and white cedar. On the lower more meisic sites black spruce, alder, and willow were dominant. When the spruce died out jack pine became the dominant member, followed in succession by oaks and the hardwoods common on the islands today (sugar maple, white, red, and chinquapin oaks, white and blue ash, American and slippery elm, hop hornbeam, basswood, and red cedar). On the lower areas succession resulted in a swamp forest association

of American elm, white ash, green ash, red maple, and silver maple. These forests existed for 8000 years until the bedrock in the Niagara region began to rise, having been released from the pressure exerted on it by the glaciers. This rise in land formed a catch basin to the west which began filling with water and flooding the postglacial valleys. A stream system developed and a characteristic floodplain vegetation grew on the surrounding hills. As the water level increased these hills became isolated as islands and the existing vegetation became the virgin forests of the Lake Erie islands 4000 years ago (Forsyth, 1977).

Reminiscent of their early development, the woodlots of the islands today still have many characteristic floodplain species even though the area now bears little resemblance to a floodplain, making them unique in Ohio and perhaps in the northeastern United States. No virgin forests exist on any of the islands today. Extensive lumbering to provide fuel for lake steamers affected all the islands, and was particularly devastating to red cedars which once covered Kelleys Island (Duncan, 1977). Much of the land was cleared for agriculture, vineyards, and for settlement.

The major forest association on the islands is sugar maple-hackberry and on the smaller islands this is the only association present with hackberry usually the dominant species. A distinctive feature of this association is lack of leaf litter due to large snail populations and extreme weather conditions (Duncan, 1977). Both these species have an efficient means of seed dispersal which is an important factor in their dominance on the more isolated islands. The larger islands, having been subject to greater influence by man, have several forest associations. Hamilton and Forsyth (1972) identified six community types on South Bass Island: (1) sugar maple-hackberry-basswood, (2) maple-oak-hickory, (3) hackberry-blue ash, (4) young hackberry, (5) box elder-green ash-maple, and (6) cedar. The first four communities represent various stages in the sugar maple-hackberry association, with young hackberry being the youngest and maple-oak-hickory being the most mature. The box elder-green ash-maple association on East Point is unique on the islands.

Another forest community not mentioned by Hamilton and Forsyth is the swamp forest association found around the edges of ponds, marshes, and in low areas. The species composition is white ash, swamp white oak, American elm, and silver maple (Duncan, 1977).

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Another forest community not mentioned by Hamilton and Forsyth is the swamp forest association found around the edges of ponds, marshes, and in low areas. The species composition is white ash, swamp white oak, American elm, and silver maple (Duncan, 1977).

Due to the conditions under which the original forests were formed, it is highly improbable that the area will ever again support a vegetation like the forest association of the immediate post-glacial period (Duncan, 1977). The characteristic species of the sugar maple-hackberry association are listed in Table 22.

Cliffs and low shelf-like rocky shores. Perhaps the most dramatic of the shoreline habitats are the high rugged cliffs along the west shore of South Bass, Kelleys, Rattlesnake, and Catawba Islands, the south shore of Middle Bass Island, the north and west shores of Gibraltar and Ballast Islands, and surrounding Green and Mouse Islands. These cliffs have two distinct vegetation zones, one at the wave splashed base of the cliffs and the other on the drier upper portion. The species inhabiting the cliff base are also common to the low shelving rocky shores of the islands. A heavy growth of filamentous algae, mainly Cladophora and Bangia sp., is attached below the water line. Herbaceous species are the sole survivors here and include grasses, and several species of wild flowers (Table 23).

The upper portion of the cliffs supports a more diverse flora being less subject to the effects of the lake water. The thin soil along the cliff edge sustains a population of lichens, mosses, algae, and herbaceous species such as chickweed, wild onion, strawberry, grasses, and sedges. Farther back are tangled vines of poison ivy, Virginia creeper, and wild grape, which yield to red cedar, dogwood, and sumac (Core, 1948). These cliff species are presented in Table 23.

Sandy beaches. Very few sandy beaches occur on the Erie Islands. Several of the beaches which do exist are used extensively by the public for recreation and the distinctive beach flora has virtually disappeared. The beach environment is particularly subject to fluctuating water levels, continuous wave action throughout most of the year, and erosive action by ice in the winter. A zonation of species exists in the form of herbaceous species along the shore and vines on the berm and into the forests or fields bordering the beach. Woody species of an early successional stage are most common here.

The sandy beaches occur at Honey Point on the southeast corner of North Bass Island, on South Bass Island east of the monument, North Bay on Kelleys Island, and along the east shore of Catawba Island. The beach at Kelleys is part of the State Park and the one on Catawba is extensively used by the public. Species common to this habitat are listed in Table 24.

TABLE 22

COMMON TREES, SHRUBS, VINES, AND HERBACEOUS SPECIES OF THE FOREST ASSOCIATION

Trees and Shrubs

Acer negundo (box elder)
A. saccharinum (silver maple)
A. saccharum (sugar maple)
Carya ovata (shagbark hickory)
Celtis occidentalis (hackberry)
Fraxinus americana (white ash)
F. pennsylvanica (green ash)
F. quadrangulata (blue ash)
Gleditsia triancanthos (honey locust)
Gymnocladus dioica (Kentucky coffee tree)
Juglans nigra (black walnut)
Juniperus virginiana (red cedar)
Morus alba (white mulberry)
M. rubra (red mulberry)
Ostrya virginiana (hop-hornbeam)
Prunus serotina (black cherry)
P. virginiana (choke cherry)
Ptelea trifoliata (hop-tree)
Quercus alba (white oak)
Q. bicolor (swamp white oak)
Q. coccinea (scarlet oak)
Q. macrocarpa (bur oak)
Q. muehlenbergii (chinquapin oak)
Q. rubra (red oak)
Ribes americanum (black currant)
R. cynosbati (wild gooseberry)
Staphylea trifolia (bladdernut)
Tilia americana (basswood)
Ulmus americana (American elm)
U. rubra (slippery elm)

Vines

Celastrus scandens (bittersweet)
Humulus lupulus (hops)
Menispermum canadense (moonseed)
Parthenocissus quinquefolia vitacea (Virginia creeper)
Rhus radicans (poison ivy)
Sicyos angulatus (bur cucumber)
Smilax rotundifolia (greenbriar)
Vitis riparia (riverbank grape)

Herbaceous Species

Alliaria officinalis (wild garlic)
Allium cernuum (wild leek)
A. tricoccuum (wild nodding onion)
Arabis laevigata (rock cress)
Arisaema atrorubens (Jack-in-the-pulpit)
Campanula americana (bellflower)
Camassia scilloides (wild hyacinth)
Carex blanda (sedge)
Circaea quadrisulcata (nightshade)
Geranium robertianum (wild geranium)
Hydrophyllum appendiculatum (water-leaf)
Hystrix patula (bottlebrush grass)
Osmorhiya longistylis (sweet Cicely)
Phlox divaricata (sweet William)
Phryma leptostachya (lopseed)
Smilacina racemosa (false Solomon seal)
S. stellata
Trillium grandiflorum (trillium)
Urtica procera (nettle)
Viola pubescens (violet)

Data Source: Stuckey and Duncan (1977)

TABLE 23

SPECIES OF SHORELINE CLIFFS AND LOW BEDROCK SHORES

Lichens
- Biatorella
- Teloschistes
- Dermatocarpon
- Psora

Mosses
- Amblystegium
- Brachythecium
- Fissidens
- Grimmia
- Gymnostomum
- Tortella
- Tortula

Aerial Algae
- Trentepohlia

Herbaceous Species

Tops of High Cliffs
- Achillea millefolium
- Allium cernuum (wild leek)
- Andropogon gerardii (turkey foot)
- Arabis pycnocarpa (rock cress)
- A. drummondii (rock cress)
- Arenaria stricta (sandwort)
- Aquilegia canadensis (columbine)
- Asplenium trichomanes (spleenwort)
- Aster pilosus (wild aster)
- Campanula rotundifolia (harebell)

Herbaceous Species

Tops of High Cliffs Continued
- Carex eburnea (sedge)
- Cerastium arvense (chickweed)
- Elymus canadensis (wild rye)
- Fragaria vesca (wild strawberry)
- Geranium robertianum (wild geranium)
- Heuchera americana (alum-root)
- Houstonia nigricans
- Panicum lanuginosum (panic grass)
- Pellea glabella (cliff-brake fern)
- Penstemon hirsutus (beard tongue)
- Prenanthes alba (white lettuce)
- Prunella vulgaris (self-heal)
- Scutellaria parvula (scullcap)
- Sedum sarmentosum (stonecrop)
- Solidago memoralis (goldenrod)
- Sphenopholis intermedia (wedge-grass)
- Viola neprophylla (violet)

Base of Cliffs and Low Bedrock Shores
- Aster pilosus (wild aster)
- Boltonia asteroides
- Carex granularis (sedge)
- Geranium robertianum (wild geranium)
- Juncus dudleyi (rush)
- J. tenuis (rush)
- Lobelia kalmii
- Lysimachia quadriflora (loosestrife)
- Lythrum alatum (loosestrife)

TABLE 23 CON'T.

SPECIES OF SHORELINE CLIFFS AND LOW BEDROCK SHORES

Herbaceous Species

Base of Cliffs and Low Bedrock Shores Continued

Panicum lanuginosum (panic grass)
Panicum virgatum (panic grass)
Penstemon hirsutus (beard tongue)
Poa compressa (Canada bluegrass)
Prunella vulgaris (self-heal)
Pycnanthemum virginianum (mint)
Senecio pauperculus (ragwort)
Solidago graminifolia (goldenrod)
Sphenopholis intermedia

Woody Species

Amelanchier sanguinea (service-berry)
A. spicata (service-berry)
Cornus drummondii (dogwood)
C. obliqua (dogwood)
Juniperus virginiana (red cedar)
Lonicara dioica (wild honeysuckle)
L. morrowi (wild honeysuckle)
Ostrya virginiana (hop-hornbeam)
Parthenocissus inserta (Virginia creeper)
Physocarpus opulifolius (ninebark)
Prunus virginiana (choke cherry)
Ptelea trifoliata (hop-tree)
Rhus radicans (poison ivy)
R. typhina (staghorn sumac)
Salix bebbiana (willow)
S. discolor (willow)

Woody Species Continued

S. interior (willow)
Solanum dulcamara (bittersweet)
Taxus canadensis (American yew)
Vitis riparia (riverbank grape)

Data Source: Stuckey and Duncan (1977)
Core (1948)

TABLE 24

DISTINCTIVE SPECIES OF SANDY SHORES

Herbaceous Species

- Asclepis syriaca (milkweed)
- Bromus tectorum (downy chess)
- Cakile edentula (sea rocket)
- Cenchurus longispinus (fern)
- Cycoloma atriplicifolia (pigweed)
- Elymus canadensis (wild rye)
- E. virginicus (wild rye)
- Euphorbia polygonifolia (spurge)
- Mirabilis nyctaginea (four o' clock)
- Oenothera biennis (evening primrose)
- Panicum virgatum (panic grass)
- Physalis heterophylla (ground cherry)
- Polanisia dodecandra (clammy weed)
- Salsola kali
- Strophostyles helvola (wild bean)
- Teucrium canadense (wood sage)
- Tripeasis purpurea (sand grass)
- Xanthium strumarium (cocklebur)

Woody Species

- Campsis radicans (trumpet creeper)
- Celastrus scandens (bittersweet)
- Cornus drummondii (dogwood)
- C. obliqua (dogwood)
- Fraxinus pennsylvanica (green ash)
- Parthenocissus quinquefolia (Virginia creeper)
- Ptelea trifoliata (hop-tree)
- Rhus radicans (poison ivy)
- Rhus typhina (staghorn sumac)
- Salix interior (willow)
- Vitis riparia (riverbank grape)

Data Source: Stuckey and Duncan (1977)

Gravel beaches and bars. The term gravel here also includes pebble and rubble beaches as all three are similar in habitat type. Gravel beaches occur on most of the islands and bars are located on Middle Bass, South Bass, Gibraltar, and Rattlesnake (see Appendix C). No permanent vegetation is found on the parts of the beach in direct contact with continuous wave action. Only a few species exist farther up the beach where waves reach only during storms and periods of high water. The beach is bordered by a row of vines, and on the larger islands by thickets of woody species.

The gravel beach shoreline areas exhibit the greatest amount of change in species composition of any habitat on the islands due to the considerable disturbance wrought by the unpredictable lake levels and weather. Characteristic species are given in Table 25.

Quarries. Three abandoned quarries exist on Kelleys Island and contain a combination of habitats: deep ponds, shallow pools, mud-flats, and dry rock surface. This area represents a disturbance created by man which has provided a habitat for survival of species which would not otherwise be found on the islands (Table 26). The quarries support an interesting combination of species which do not occur together in other locations. Species characteristic of rocky cliffs, ponds, marshes, gravel beaches, and open fields are all found here. Another habitat has recently been formed by debris collected from the Kelleys Island beaches. Quarry species are listed in Table 27.

Open fields. The open field habitat is also one created largely by man and covers vineyards, fallow fields, dumps, and roadside areas. This habitat exhibits a high diversity of both native and non-indigenous species depending on moisture conditions, disturbances, and proximity of woodlots.

At one time the larger islands were practically covered with vineyards, but many have been abandoned at various times since 1900. Today most of the active vineyards are on North Bass and Middle Bass Islands with several acres still under cultivation on South Bass Island. The active vineyards show a greater species diversity particularly in herbaceous plants, then is seen in the abandoned vineyards, while the abandoned vineyards and fallow fields represent various stages of succession to a sugar maple-hackberry forest association (Werblan, 1976).

Aquatic habitats. There are three aquatic habitats on the islands: open lake, bay, and pond/marsh. Stuckey (1977) records only seven

TABLE 25

DISTINCTIVE SPECIES OF GRAVEL BEACHES AND BARS

Herbaceous Species

Asclepias incarnata (milkweed)
Geranium robertianum (wild geranium)
Parietaria pennsylvanica
Polygonum lapathifolium pennsylvanicum
Teucrium canadense (wood sage)

Woody Species

Acer negundo (boxelder)
Celtis occidentalis (hackberry)
Cornus drummondii (dogwood)
C. obliqua (dogwood)
Fraxinus americana (white ash)
F. pennsylvanica (green ash)
Parthenocisus vitacea (Virginia creeper)
Platanus occidentalis (sycamore)
Populus deltoides (cottonwood)
P. tremuloides (quaking aspen)
Rhus radicans (poison ivy)
Salix alba (willow)
S. amygdaloides (willow)
S. fragilis (willow)
Tilia americana (basswood)
Ulmus americana (American elm)
Vitis riparia (riverbank grape)

Data Source: Stuckey and Duncan (1977)

TABLE 26

SPECIES IN THE QUARRIES ON KELLEYS ISLAND WHICH ARE RARE OR UNKNOWN ELSEWHERE ON THE ERIE ISLANDS

Asclepias vericillata (milkweed)	Leucospora multifida
Carex eburnea (sedge)	Liparis loeselii (twayblade)
C. garberi (sedge)	Ludwigia palustris (primrose)
C. granularis (sedge)	L. polycarpa (primrose)
C. hystericina (sedge)	Lythrum alatum (loosestrife)
C. lanuginosa (sedge)	Najas marina
C. stricta (sedge)	Potamogeton illinoensis (pondweed)
Dryopteris intermedia (fern)	Rosa eglanteria (sweetbrier)
D. spinulosa (fern)	Satureja arkansana
Dryopteris x tripolidea (fern)	Scirpus acutus (bulrush)
Eleocharis compressa (spike rush)	S. pendulus (bulrush)
Eupatorium altissimum	Scleria verticillata (nut rush)
Galium concinnum (bedstraw)	Scutellaria parvula (scullcap)
Helianthus maximilianii (sunflower)	Sisyrinchium albidum (blue-eyed grass)
Houstonia nigricans	Spiranthes cernua
Isanthus brachiatus (false pennyroyal)	Sporobolus vaginiflorus (dropseed)
Juncus alpinus (rush)	Solidago nemoralis (goldenrod)
Juncus alpinus x torreyi (rush)	Thelypteris palustris (marsh fern)

Data Source: Stuckey and Duncan (1977)

TABLE 27

DISTINCTIVE SPECIES OF THE KELLEYS ISLAND QUARRIES

Herbaceous Species

Pools and Ponds

- Ranunculus longirostris (crowfoot)
- Potamogeton illinoensis (pond weed)
- P. foliosus (pond weed)
- Najas marina

Wet Flats

- Alisma plantago-aquatica
- Asclepias incarnate (milkweed)
- Bidens cernuus (beggar ticks)
- Carex comosa (sedge)
- C. garberi (sedge)
- C. granularis (sedge)
- C. hystericina (sedge)
- C. lanuginosa (sedge)
- C. stricta (sedge)
- C. vulpinoidea (sedge)
- Cyperus ferruginescens
- C. rivularis
- Dryopteris intermedia
- D. spinulosa (fern)
- D. x triploidea (fern)
- Eleocharis compressa (spike rush)
- E. erythropoda (spike rush)
- Eupatorium perfoliatum
- Juncus alpinus (rush)
- J. alpinus x torreyi (rush)
- J. dudleyi (rush)
- J. nodosus (rush)

Wet Flats Continued

- Juncus torreyi (rush)
- Leucospora multifida
- Ludwigia palustris (primrose)
- L. polycarpa (primrose)
- Lycopus americanus
- L. uniflorus
- Lythrum alatum (loosestrife)
- Mentha arvensis (mint)
- Mimulus ringens (monkey flower)
- Phyla lanceolata (fog-fruit)
- Scirpus acutus (bulrush)
- S. pendulus (bulrush)
- S. validus (bulrush)
- Scleria verticillata (nut rush)
- Scutellaria lateriflora (skullcap)
- Senecio pauperculus (ragwort)
- Strophostyles helvola (wild bean)
- Typha angustifolia (cattail)
- Verbena hastata

Dry Habitats

- Achillea millefolium
- Allium cernuum (wild leek)
- Andropogon gerardii (turkeyfoot)
- Anemone virginica (anemone)
- Arabis pycnocarpa (rock cress)
- Asclepias tuberosa (milkweed)

Data Source: Stuckey and Duncan (1977)

TABLE 27 CON'T.

DISTINCTIVE SPECIES OF THE KELLEYS ISLAND QUARRIES

Herbaceous Species

Dry Habitats Continued

Asclepias tuberosa (milkweed)
Carex eburnea (sedge)
Eupatorium altissimum
Festuca pratensis (fescue)
Galium concinnum (bedstraw)
Geranium robertianum (wild geranium)
Helianthus maximilianii (sunflower)
Houstonia nigricans
Hypericum perforatum
Isanthus brachiatus (false pennyroyal)
Juncus bufonius (rush)
J. tenuis (rush)
Liparis loeselii (twayblade)
Monarda fistulosa (horse-mint)
Panicum lanuginosum (panic-grass)
Panicum virgatum (panic-grass)
Parietaria pennsylvanica
Penstemon hiruutus (beard tongue)
Poa compressa (Canada bluegrass)
Polanisia dodecandra (clammy weed)
Potentilla novegica
Prunella vulgaris (self-heal)
Pycnanthemum virginianum (mountain-mint)
Satureja arkansana
Scutellaria parvula (skullcap)
Sisyrinchium albidum (blue-eyed grass)
Solidago graminifolia (golden rod)

Herbaceous Species

Dry Habitats Continued

Solidago nemoralis (goldenrod)
Spiranthes cernuus
Sporobolus vaginiflorus (dropseed)
Thelypteris palustris (marsh fern)
Verbena simplex

Woody Species

Celtis occidentalis (hackberry)
Cornus drummondii (roughleaf dogwood)
C. obliqua (silky dogwood)
Fraxinus pennsylvanica (green ash)
F. quadrangulata (blue ash)
Juniperus virginiana (red cedar)
Lonicera dioica (wild honeysuckle)
L. morrowii
Morus alba (white mulberry)
Ostrya virginiana (hop-hornbeam)
Parthenocissus vitacea (Virginia creeper)
Physocarpus opulifolius (ninebark)
Populus deltoides (cottonwood)
P. tremuloides (quaking aspen)
Prunus virginiana (choke cherry)
Ptelea trifoliata (hop-tree)
Quercus muehlenbergii (chinquapin oak)
Rhus aromatica (fragrant sumac)
R. glabra (smooth sumac)
R. radicans (poison ivy)

TABLE 27 CON'T.

DISTINCTIVE SPECIES OF THE KELLEYS ISLAND QUARRIES

Woody Species

Rhus typhina (staghorn sumac)
Rosa micrantha (sweetbrier)
R. setigera (prairie rose)
Rubus occidentalis (black raspberry)
Salix discolor (pussy willow)
S. interior (sandbar willow)
S. nigra (black willow)
Solanum dulcamara (bittersweet)
Vitis riparia (riverbank grape)

species growing in the open lake around the islands due to the turbidity of the lake water (Table 28).

The bays of the islands are located on the north shores of South Bass and Kelleys Islands and on the west shore of North Bass. The bay at South Bass Island has been the one most studied due to its close proximity to the Franz Theodore Stone Laboratory and the State Fish Hatchery. It is comprised of three sections: Put-in-Bay Harbor to the east, Squaw Harbor in the middle, and Fishery Bay to the west. Gibraltar Island to the north protects the bay from the open lake and forms a gravel bar separating Fishery Bay from Squaw Harbor. The entire harbor section is lined with boat docks and steel and concrete retaining walls.

A survey by Pieters in the late 1800's showed 40 species of aquatic vascular plants growing in the bay. Stuckey (1977) lists only 20 of the original species remaining with only two of these being common. All floating vegetation and marsh grasses are either nonexistent or present on a very small scale. Dredging, construction of retaining walls, increased use of motor boats, dumping of wastes and domestic sewage, runoff from vineyards near the bay, and the dramatic rise and fall of water levels during the last several years are all contributing factors to the demise of the once abundant aquatic flora (Stuckey, 1971). Species found in the bays today are given in Table 29.

The major pond/marsh habitats include Carp Pond on Kelleys Island, Terwilliger's Pond on South Bass Island, Haunck's Pond on Middle Bass Island, Smith's Pond, Fox's Marsh, Mound Pond, and Honey Point on North Bass Island. These ponds are subject to fluctuations in the lake level and at times largely mudflats or even completely dry.

Four ponds on the islands have been filled in or altered. Fischer's Pond on Middle Bass Island was filled in 1967 for the Burgundy Bay Resort Development. It was the site of the only record of Acer rubrum (red maple) for the islands. Wehrle's Pond, also on Middle Bass, was converted to a marina. The marina is rarely used now due to the closing of Lonz's Winery, and with the recent high water the area is reverting to pond conditions. Kelleys' Pond on southeast Kelleys Island was made into the Seaway Marina in 1958, which was soon abandoned. The area began to return to pond conditions until recently when it was again developed as a marina. Perry's Monument is located on the former site of Chapman's Pond, which was filled in in 1912 for construction of the monument. Some of the area reverted to marsh between

TABLE 28

SPECIES OF THE OPEN LAKE

Butomus umbellatus f. vallisneriifolius (flowering rush)
Heteranthera dubia (mud-plantain)
Myriophyllum exalbescens
Potamogeton nodosus (pondweed)
P. pectinatus (pondweed)
P. richardsonii (pondweed)
Vallisneria americana (tape-grass)

Data Source: Stuckey and Duncan (1977)

TABLE 29

SPECIES OF THE BAYS

Asclepias incarnata (swamp milkweed)
Butomus umbellatus f. vallisneriifolius (flowering rush)
Carex comosa (sedge)
C. frankii (sedge)
Ceratophyllum demersum (hornwort)
Elodea canadensis
Elodea nuttallii
Heteranthera dubia (mud plantain)
Juncus torreyi (rush)
Justicia americana (water willow)
Myriophyllum exalbescens
Nelumbo lutea (lotus lily)
Potamogeton crispus (pondweed)
P. filiformis (pondweed)
P. pectinatus (pondweed)
P. pusillus var. tenuissimus (pondweed)
P. richardsonii (pondweed)
Rumex verticillatus (water-dock)
Sagittaria latifolia (arrow-head)
Scirpus acutus (bulrush)
S. americanus (bulrush)
S. atrovirens (bulrush)
S. fluviatilis (bulrush)
S. validus (bulrush)
Sparganium eurycarpum (bur-reed)
Typha angustifolia (cattail)
Typha latifolia (cattail)
Vallisneria americana (tape-grass)
Zannichellia palustris (horned pondweed)

Data Source: Stuckey and Duncan (1977)

1973 and 1975 when high water broke the retaining wall, but the area has since been refilled (Stuckey, 1977). Common pond species appear in Table 30.

Turtle Island. In the early 1800's this island was tree covered (Thal, 1935), and when the island was sold in 1904 the following appeared in the Toledo Blade:

> "Grass does not flourish upon the island's sandy soil, but trees and vegetables thrive there. Almost the entire island is covered with trees and shrubbery, but a frugal, thrifty keeper reserved a quarter-acre plot for a kitchen garden" (Toledo Blade, 12/5/04).

Evidently, some of the garden plants still thrive on Turtle Island. The present owner reports that wild garlic (Allium vineale), dill (Anethum graveolens) and some peach trees are present on the island, the garlic being especially abundant.

Several trips to the island have been made by CLEAR personnel in the early spring of 1977. At this time the island is mostly barren sand on the north and northeast sides. The south and southwest portions are thickly covered with staghorn sumac (Rhus typhina) and cottonwood trees (Populus deltoides). Several cottonwoods are quite large with diameters of 3 to 3-1/2 feet.

Conclusion. Although man has done much to alter the native vegetation of the Lake Erie Islands, he has also introduced many new species and created the newly disturbed habitats necessary for their survival. In a comparison with earlier surveys Stuckey and Duncan (1977) estimate an 18% loss of original native species versus a 12% gain of species new to the islands. Seventy-five percent of the non-indigenous species are of European origin, due primarily to settlement by German immigrants and climatic and physiographic conditions similar to those of Europe. Some of the well-established non-indigenous species are now rare in surrounding parts of Ohio and Ontario. Table 31 lists the number of species and their relative change over time.

Even with all the disturbances brought by man, the islands remain a unique area. Efforts are needed to preserve each habitat.

TABLE 30

SPECIES OF THE POND ASSOCIATION

Submersed Species
- Ceratophyllum demersum (hornwort)
- Elodea canadensis
- Myriophyllum exalbescens
- Potamogeton foliosus (pondweed)
- P. pectinatus (pondweed)
- P. pusillus var. tenuissimus (pondweed)
- Ranunculus longirostris (buttercup)
- Utricularia vulgaris (bladderwort)

Floating Species
- Lemna minor (duckweed)
- Spirodela polyrhiza (duckweed)
- Wolffia columbiana
- Wolffia punctata

Attached Floating-Leaved Species
- Decodon verticillatus (water willow)
- Hibiscus moscheutos (rose mallow)
- Nuphar advena (yellow water lily)
- Nymphaea tuberosa (water lily)
- Polygonum amphibium var. emersum
- Pontederia cordata

Species at Edge of Pond
- Alisma plantago-aquatica
- Amaranthus tuberculatus
- Asclepias incarnata (swamp milkweed)
- Bidens cernus (beggar ticks)

Species at Edge of Pond Continued
- Bidens connatus (beggar ticks)
- B. frondosus (beggar ticks)
- Boehmeria cylindrica
- Butomus umbellatus (flowering rush)
- Calamogrostis canadensis
- Cardamine pennsylvanica
- Carex cristatella (sedge)
- C. stipata (sedge)
- C. vulpinoidea (sedge)
- Cephalanthus occidentalis
- Cornus drummondii (dogwood)
- C. obliqua (dogwood)
- Cyperus ferruginescens
- Eleocharis obtusa (spike rush)
- Epilobium glandulosum
- Eupatorium perfoliatum
- Fraxinus pennsylvanica (green ash)
- Glyceria striata (manna grass)
- Impatiens capensis
- Iris virginica (blue flag)
- Juncus dudleyi (rush)
- J. effusus (rush)
- J. torreyi (rush)
- Leersia oryzoides (cut grass)
- Lindernia dubia (false pimpernel)
- Lobelia siphilitica
- Lycopus americanus
- Mentha arvensis (mint)

TABLE 30 CON'T.

SPECIES OF THE POND ASSOCIATION

Species at Edge of Pond Continued	Trees
Mimulus ringens (monkey flower)	Acer saccharinum (silver maple)
Penthorum sedoides (stonecrop)	Fraxinus pennsylvanica (green ash)
Phalaris arundinacea (canary grass)	Platanus occidentalis (sycamore)
Polygonum lapathifolium	Populus deltoides (cottonwood)
P. persicaria	Quercus macrocarpa (bur oak)
P. punctatum	Salix amygdaloides (willow)
Ranunculus sceleratus (buttercup)	Solanum dulcamara (bittersweet)
Rorippa palustris var. fernaldiana (cress)	Ulmus americana (American elm)
R. palustris var. hispida (cress)	
Rosa palustris (swamp rose)	
Rumex verticillatus (water dock)	
Sagittaria latifolia (arrow-head)	
Salix interior (willow)	
Sambucus canadensis (elder)	
Scirpus atrovirens (bulrush)	
S. fluviatilis (bulrush)	
S. pungens (bulrush)	
S. validus (bulrush)	
Scutellaria epilobiifolia (scullcap)	
S. lateriflora (skullcap)	
Sparganium eurycarpum (bur-reed)	
Stachys palustris (nettle)	
Typha angustifolia (cattail)	
Verbena hastata	

Data Source: Stuckey and Duncan (1977)

TABLE 31

NUMBER OF SPECIES AND THEIR RELATIVE CHANGE OVER TIME FOR OHIO AND ONTARIO ISLANDS

Island	Moseley(1899)	Core(1948)	Stuckey & Duncan (1977)	Percent Increase 1899–1939	Percent Increase 1939–1975	Percent of Island Flora Not Seen by Stuckey and Duncan[3]
South Bass	424 (439)[1]	516 (559)[1]	613 (508)[2]	17.8	15.8	17.1 (105)
Middle Bass	299 (306)	345 (364)	412 (325)	13.3	16.3	20.9 (86)
North Bass	278 (282)	330 (337)	395 (316)	15.8	16.4	19.8 (78)
Gibraltar	–	169 (173)	211 (169)	–	19.9	19.4 (41)
Kelleys	431 (461)	427 (471)	522 (424)	9.4	18.2	18.8 (98)
Pelee	–	410 (450)	595 (502)	–	-31.1	16.5 (93)
Green	113 (115)	186 (190)	208 (166)	39.2	10.6	20.2 (42)
Rattlesnake	192 (192)	179 (186)	223 (164)	-7.3	19.7	26.4 (59)
Ballast	–	92 (93)	99 (67)	–	7.1	32.3 (32)
Sugar	–	98 (98)	147 (125)	–	6.1	14.9 (22)
Mouse	–	65 (66)	136 (117)	–	-52.2	14.0 (19)
Middle	–	105 (107)	169 (153)	–	-37.8	9.5 (16)
Starve	–	35 (37)	88 (74)	–	60.2	15.9 (14)
East Sister	–	62 (63)	128 (115)	–	-51.6	10.2 (13)
Middle Sister	–	74 (76)	83 (59)	–	10.8	6.5 (24)
West Sister	–	65 (67)	108 (95)	–	-39.8	12.0 (13)
Hen	–	82 (83)	115 (90)	–	28.7	21.7 (25)
Big Chicken	–	17 (17)	30 (18)	–	-43.3	40.0 (12)
Little Chicken	–	30 (31)	32 (1)	–	6.6	97.8 (31)
North Harbor	–	47 (47)	55 (34)	–	14.5	38.2 (21)
Lost Ballast	–	38 (38)	47 (32)	–	19.1	31.2 (15)

[1] Number of species corrected to current nomenclature; figure in parentheses is the number of species listed by the investigator.

[2] Total number of species known from island; figure in parentheses is the number of species observed by Stuckey and Duncan (1977).

[3] Percent of total species not observed by Stuckey and Duncan; figure in parentheses is actual number of species not observed.

type in order to maintain rare and endangered species. Loss of additional native vegetation on the islands will result in reduction of the terrestrial and aquatic faunas which rely on it for feeding and breeding purposes, as well as a decrease in aesthetic appeal. Areas suggested for preservation are Duff's Woods on South Bass Island representing the most mature woodlot, the unique quarry habitat in the North Quarry on Kelleys Island, Carp Pond and Haunck's Pond, Fox's Marsh, and Green Island.

Detailed vegetation maps for each island are presented in the Appendix.

TABLE 32
MONTHLY MEAN PHYTOPLANKTON POPULATIONS
(organisms/liter)

TAXA	July 1973	Aug 1973	Sept 1973	Oct 1973	Nov 1973	Dec 1973	Jan 1974	Feb 1974	March 1974	April 1974	May 1974
BACILLARIOPHYCEAE (Diatoms)											
Asterionella sp.	41	13		3	4279	1588	1906	3208	8124	6517	5048
Cyclotella-Stephanodiscus	29	20							104		
Cymatopleura sp.	4		2			7					
Fragilaria sp.	38	109	95	226	1154	1553	1809	2774	6539	4808	6824
Gyrosigma sp.	36	14	7	5	13	7	73		32	49	
Melosira sp.	133	95	1768	6723	9399	7314	16512	31378	77447	34177	55275
Naviculoid	89	6	4	6	8		69	21	226	49	
Surirella sp.	2			3	5					44	
Synedra sp.							15	133	17		2993
Tabellaria sp.	43	7		14	129	372	807	1436	4091	3990	20806
Subtotal	415	264	1876	6980	14987	10841	21191	38950	96580	49634	90946
CHLOROPHYCEAE (Green Algae)											
Actinastrum sp							7				
Ankistrodesmus sp.					8						
Closteriopsis sp.	6					204	214	221	952	220	
Closterium sp.	2	2			5			10			117
Coelastrum sp.		63	65	5	3	4	8				
Cosmarium sp.		20						40		42	
Mougeotia sp.								21			407
Pandorina sp.		13		3	3				17	49	
Pediastrum sp.	962	1552	1239	2090	832	261	13		144		117

TABLE 32 CONT.
MONTHLY MEAN PHYTOPLANKTON POPULATIONS
(organisms/liter)

TAXA	July 1973	Aug 1973	Sept 1973	Oct 1973	Nov 1973	Dec 1973	Jan 1974	Feb 1974	March 1974	April 1974	May 1974
Scenedesmus sp.	10			14	283	8			17		
Spirogyra sp.	4	2									
Staurastrum sp	70	133	59	47	24	4			69		
Volvox sp.		11			5						
Subtotal	1054	1796	1363	2159	1163	481	242	292	1199	311	641
DINOPHYCEAE (Dinoflagellates)											
Ceratium hirundinella	376	426	105	51	3	4					111
MYXOPHYCEAE (Blue-green algae)											
Anabeana sp.	15	32	67	27	5		8				
Aphanizomenon-Oscillatoria	174	165	4807	1059							544
Microcystis sp.	4	86	41	35	9				18		
Subtotal	193	283	4915	1121	14		8		18		544
XANTHOPHYCEAE (Yellow-green algae)											
Tribonema sp.	488	46	32	216	152						
TOTAL	2526	2815	8291	10527	16319	11326	21441	39242	97797	49945	92242

Reutter and Reutter (1977)

Plankton

Phytoplankton. The phytoplankton in the island area consists mainly of diatoms (Bacillariophyceae), green algae (Chlorophyceae), and blue-green algae (Myxophyceae). The major species present and their monthly populations are listed in Table 32.

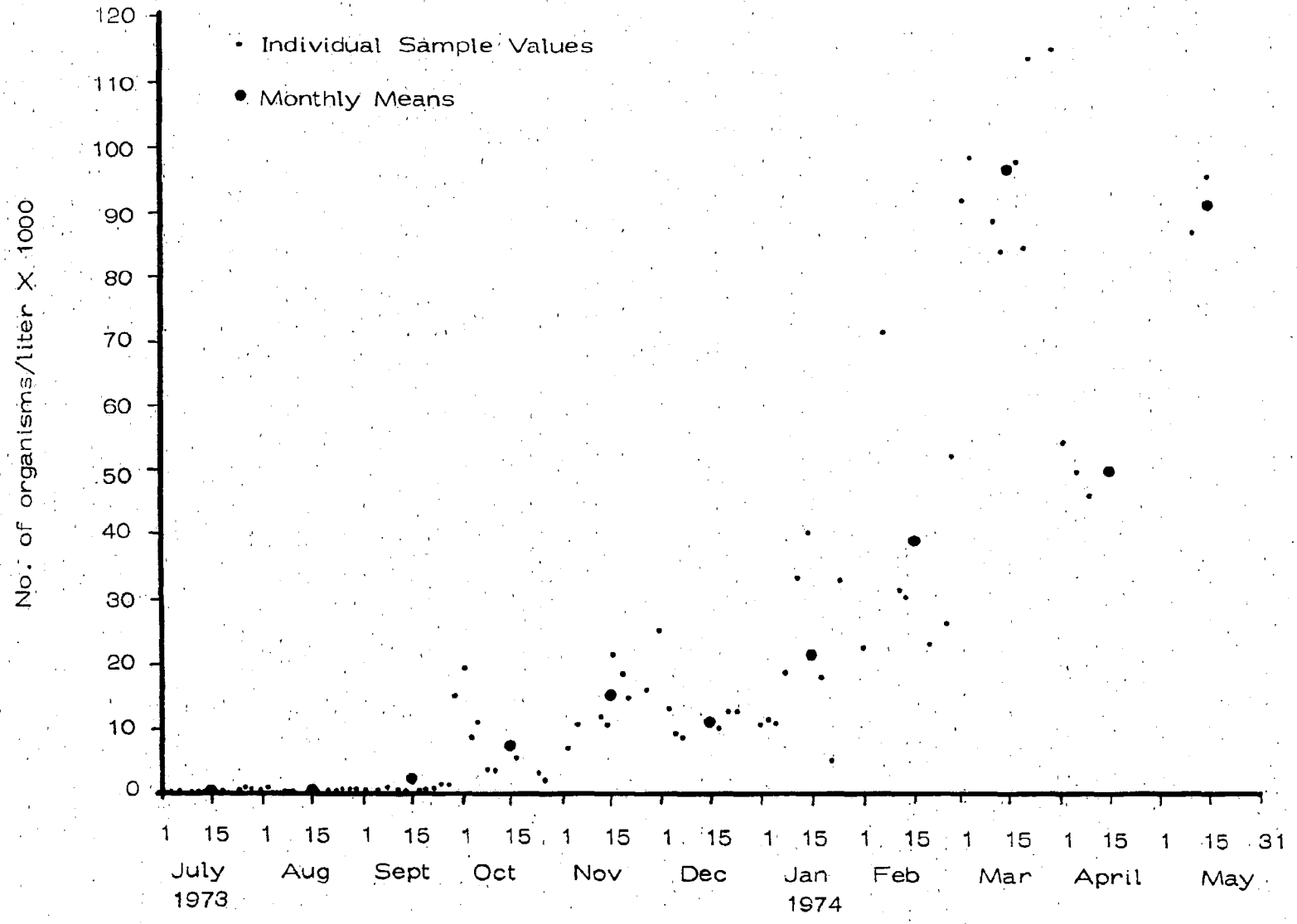
Diatoms comprise the greatest percentage of the total phytoplankton population with a major pulse in the spring and a smaller pulse in the fall (Reutter and Reutter, 1977). They are present almost exclusively during the winter. All the species occurring in the greatest numbers, such as Melosira, Fragilaria, Asterionella, and Synedra are indicators of eutrophic conditions. The abundance of diatoms when graphed according to monthly populations (Figure 25) closely resembles the graph of monthly total phytoplankton population (Figure 26), indicating the influence of the diatom population on the phytoplankton community (Reutter and Reutter, 1977).

The planktonic green algae become most plentiful during midsummer as the lake water warms up. Studies conducted by Tiffany (1934), Chandler (1940, 1942a & b, and 1944), Chandler and Weeks (1945), Vila-Pinto (1964), Taft and Taft (1971), Britt, Addis, and Engel (1973), and Reutter and Reutter (1977) indicate Chlorophyceae as the most diverse member of the phytoplankton community. The dominant species in the most recent study is Pediastrum. A fair amount of fragments of the filamentous, attached green algae, Cladophora glomerata, which covers the rocky shoreline, also occurs in the plankton (Hartman, 1973). Figure 27 shows the monthly variation in Chlorophycean populations.

The blue-green algae are most common during late summer as shown in Figure 28. A bloom of Oscillatoria and Aphanizomenon often occurs during the "dog days" of August (Hartman, 1973).

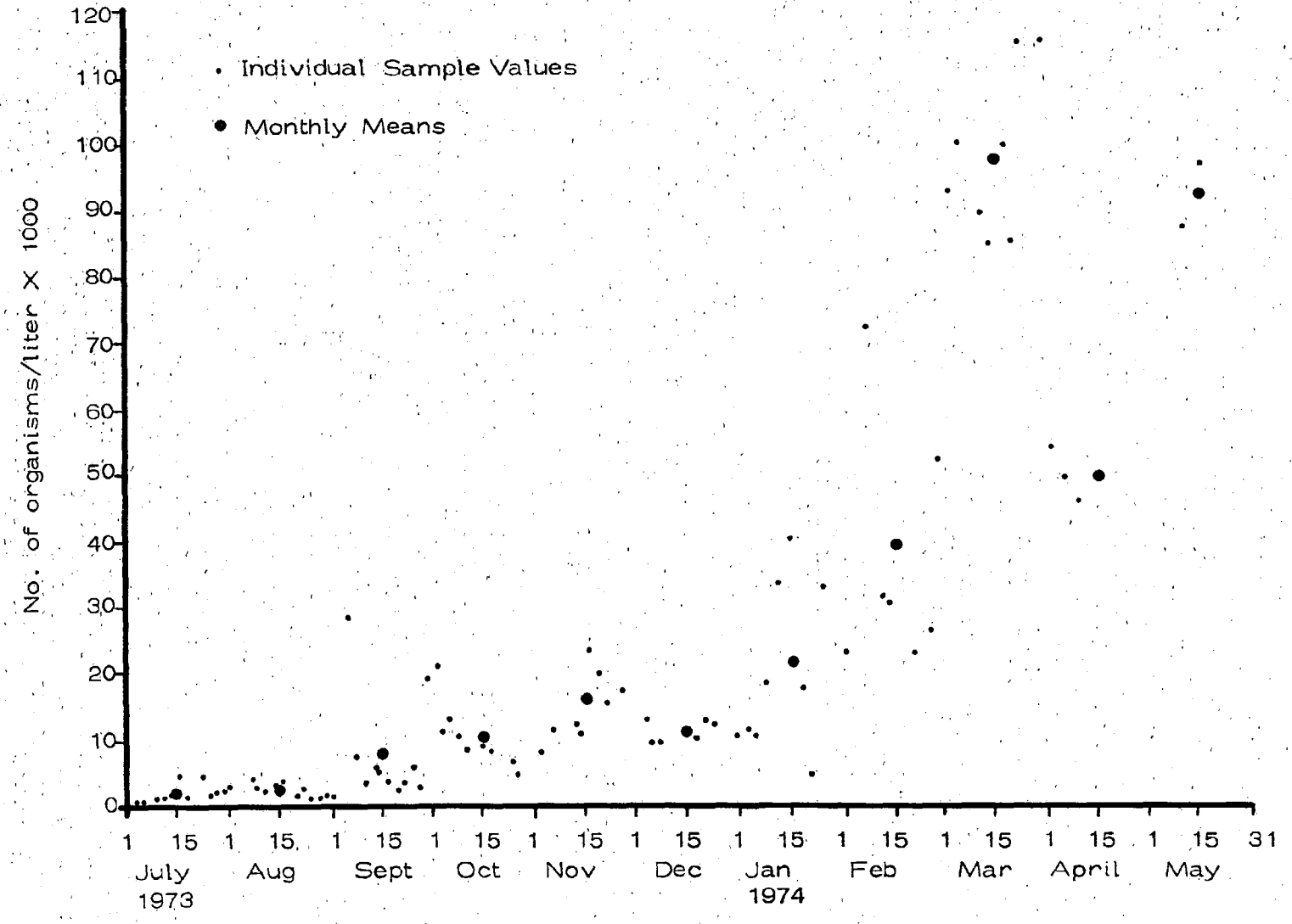
Zooplankton. The bulk of the zooplankton is composed of Copepoda, particularly cyclopoid copepods, but rotifers and cladocerans are also abundant. Rotifer populations are the most diverse. A zooplankton pulse (Figure 29) normally occurs in June with increases in rotifers, copepods, and cladocerans as depicted in Figures 30, 31 and 32, respectively. A list of zooplankton as recorded by Reutter and Reutter (1975) appears in Table 33.

FIGURE 25.
BACILLARIOPHYCEAN POPULATIONS AT PUT-IN-BAY



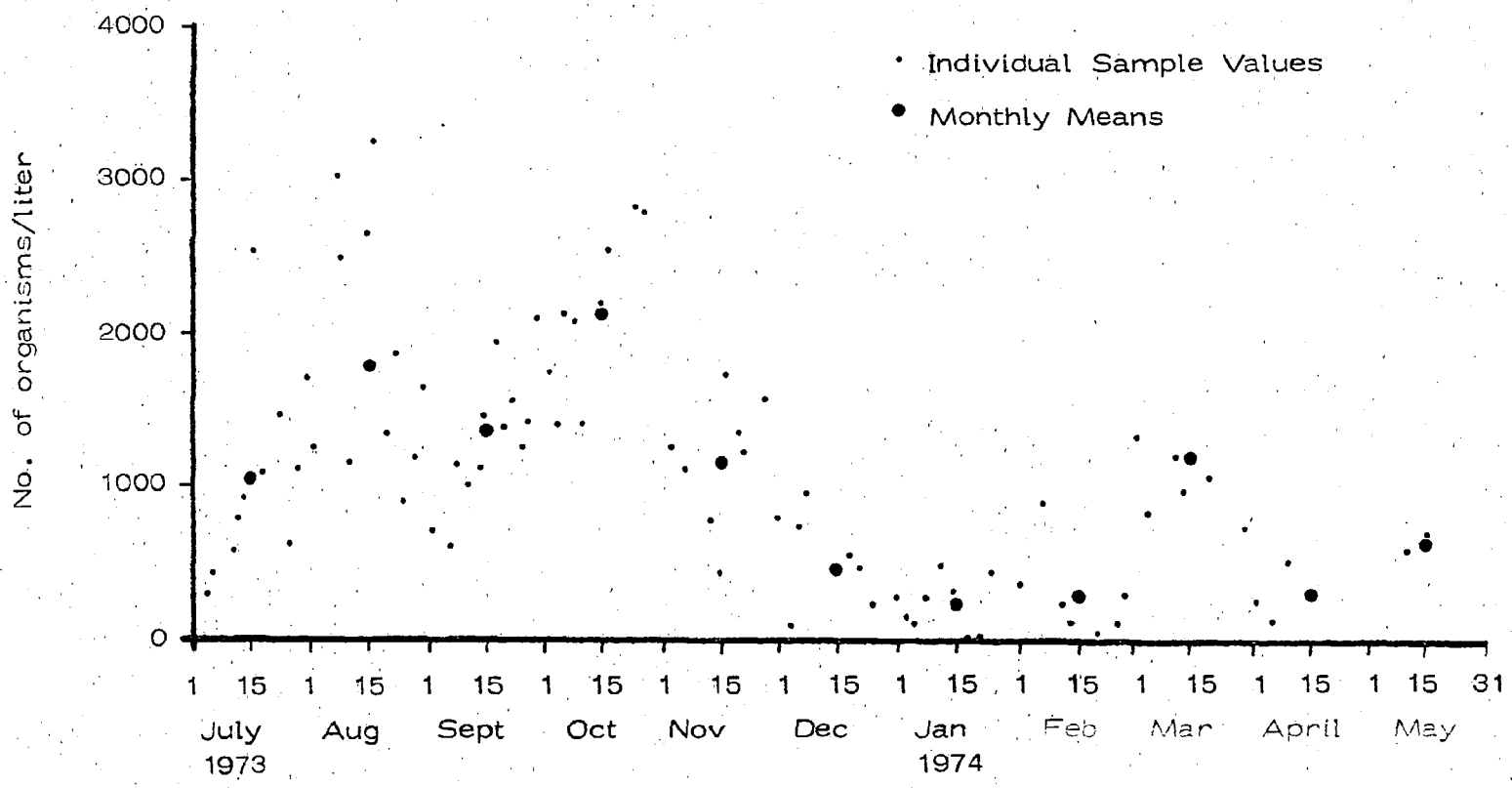
Reutter and Reutter (1977)

FIGURE 26.
TOTAL PHYTOPLANKTON POPULATIONS AT PUT-IN-BAY



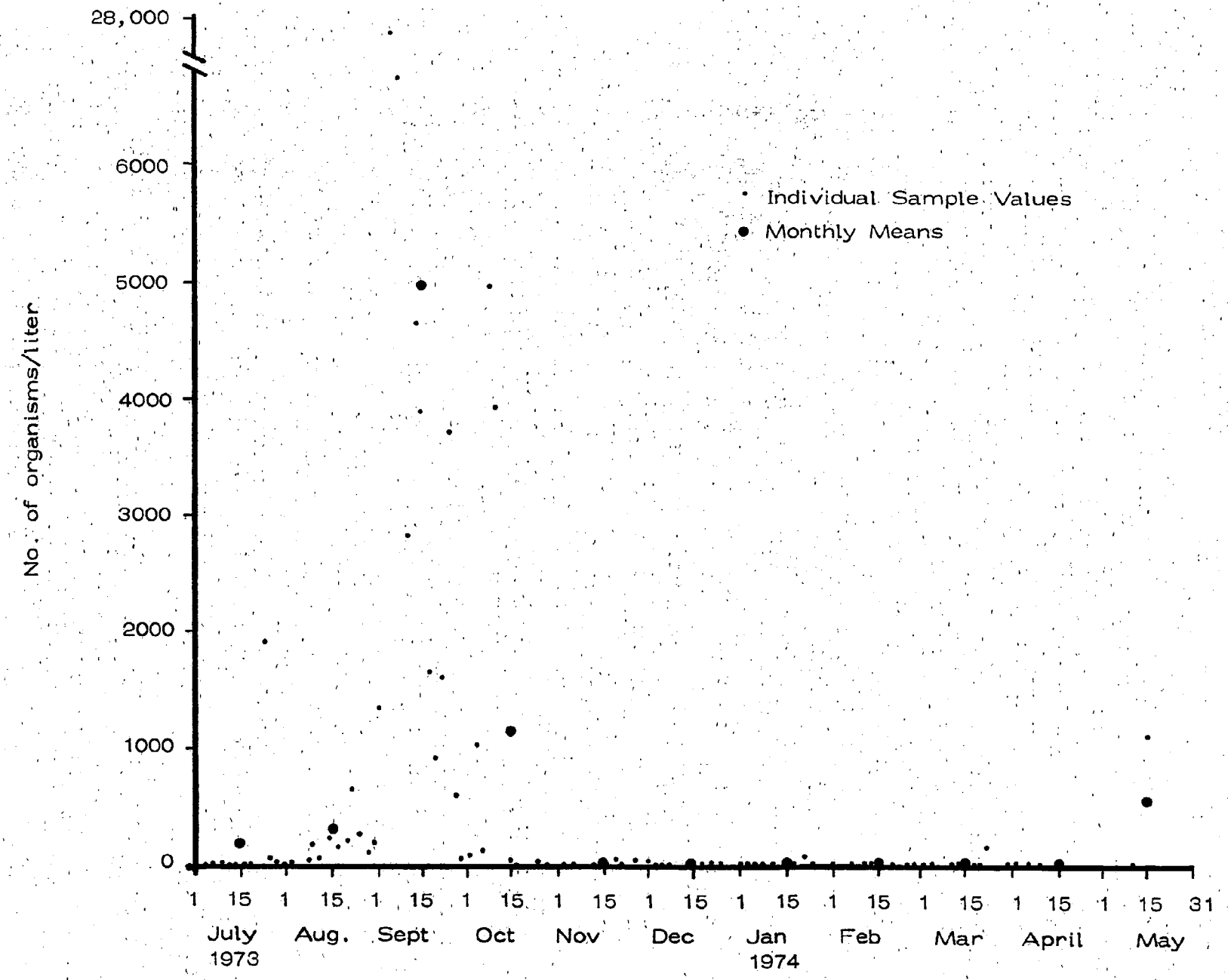
Reutter and Reutter (1977)

FIGURE 27.
CHLOROPHYCEAN POPULATIONS AT PUT-IN-BAY



Reutter and Reutter (1977)

FIGURE 28.
MYXOPHYCEAN POPULATIONS AT PUT-IN-BAY



Reutter and Reutter (1977)

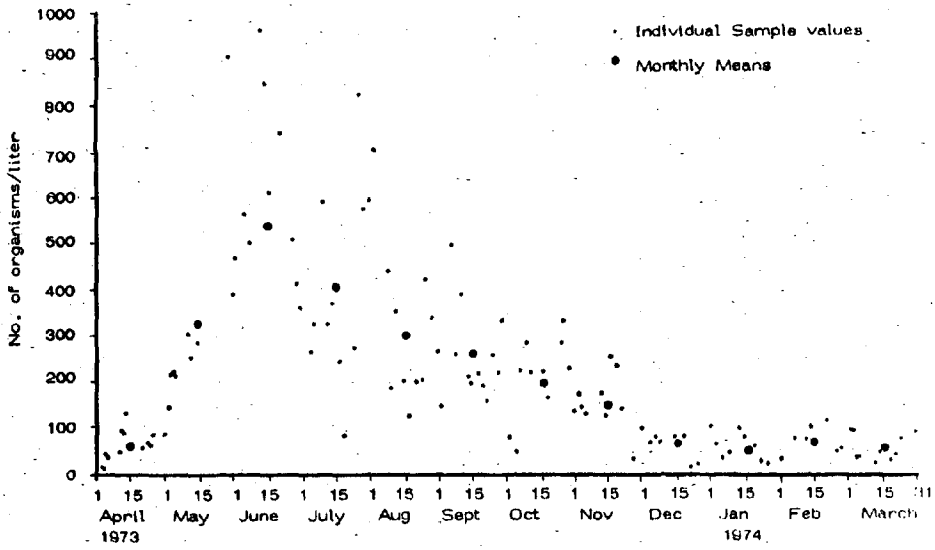


FIGURE 29 TOTAL ZOOPLANKTON POPULATIONS AT PUT-IN-BAY: 2 APRIL 1973-29 MARCH 1974.

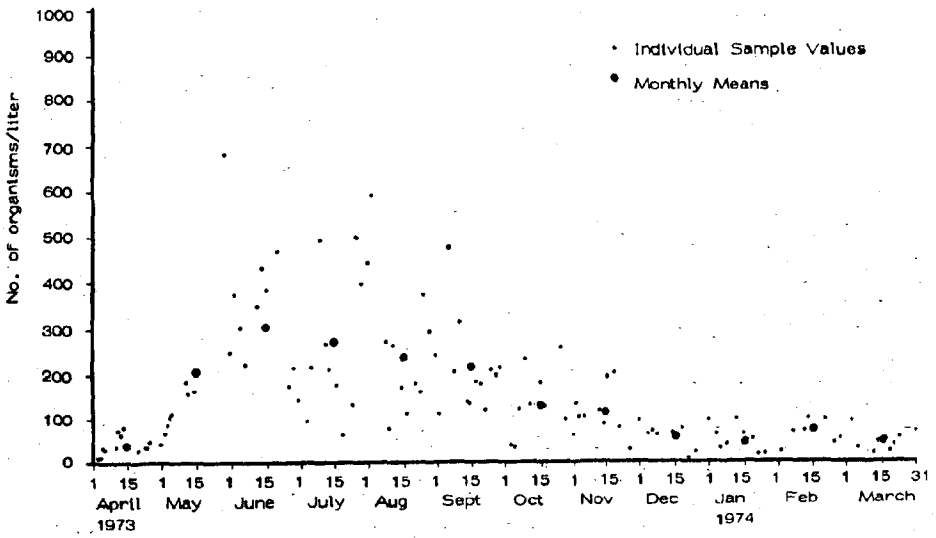


FIGURE 30 ROTIFER POPULATIONS AT PUT-IN-BAY: 2 APRIL 1973-29 MARCH 1974.

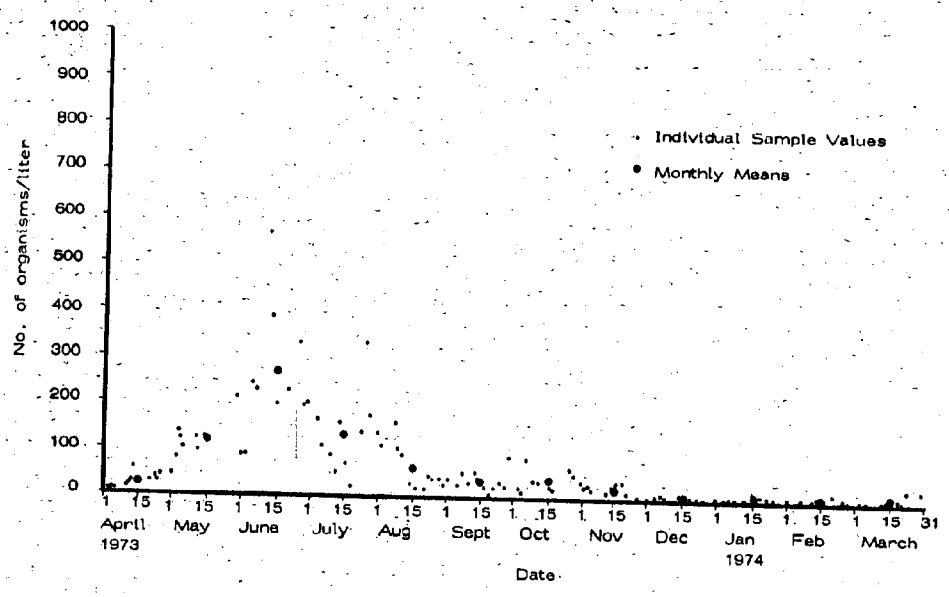


FIGURE 31 TOTAL COPEPOD POPULATIONS AT PUT-IN-BAY: 2 APRIL 1973-29 MARCH 1974.

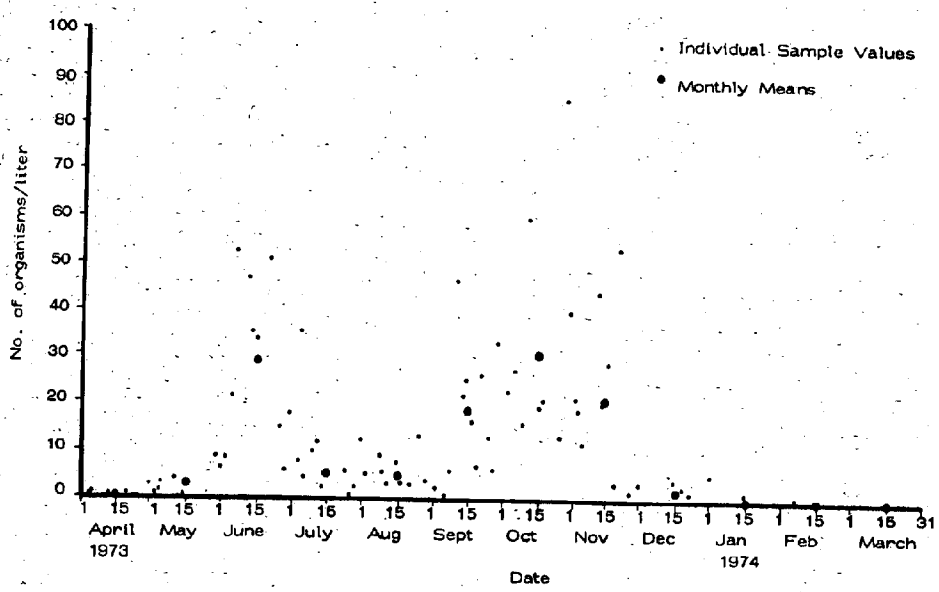


FIGURE 32 TOTAL CLADOCERAN POPULATIONS AT PUT-IN-BAY: 2 APRIL 1973-29 MARCH 1974.

TABLE 33

ZOOPLANKTON OF WESTERN LAKE ERIE

ROTIFERA
- Asplanchna giroidi
- Asplanchna priodonta
- Brachionus angularis
- Brachionus calyciflous
- Brachionus havanaensis
- Brachionus patulus
- Brachionus quadridentatus
- Brachionus urceolaris
- Chromogaster ovalis
- Conochiloides sp.
- Euchlanis sp.
- Filinia terminalis
- Hexarthra mira
- Kellicottia longispina
- Keratella cochlearis
- Keratella quadrata
- Lecane luna
- Lecane lunaris
- Lepadella patella
- Mytilina sp.
- Notholca acuminata
- Notholca squamula
- Pleosoma sp.
- Polyarthra sp.
- Pompholyx sulcata
- Synchaeta sp.
- Trichocera clyindrica
- Trichocera multicrinis

COPEPODA
- Diaptomas sp.
- Eurytemora sp.
- Immature calanoid copepods
- Cyclops sp.
- Mesocyclops sp.
- Immature cyclopoid copepods
- Nauplii

CLADOCERA
- Alona sp.
- Bosmina sp.
- Camptocerus sp.
- Ceriodaphnia sp.
- Chydorus sp.
- Daphnia galeata
- Daphnia retrocurva
- Diaphanosoma sp.
- Holopedium gibberium
- Leptodora kindtii

Data Source:

Reutter and Reutter (1975)

Benthic Organisms

The bottom community of the lake and ponds around the Erie Islands is an accumulation of diverse and abundant organisms occurring on several different substrates: mud, sand, clay, gravel, and rock. The species and abundance of organisms present are dependent upon substrate, water quality, and dissolved oxygen.

Oligochaetes and chironomids (midges) occur most often and most universally. The tubificid oligochaete, Limnodrilus, dominates the bottom fauna comprising 61% of the total fauna, particularily in soft mud which is the most common sediment. Chironomid larvae make up less than 20% and sphaeriid clams 10% of the benthos (Britt, et al., 1977). The remaining percentage of the benthic community includes leeches, amphipods, polychaete worms, mysids, coelenterates, flatworms, mollusks, crustaceans, and caddisflies. The aquatic isopod, Asellus r. racovitazi, accounts for most of this remaining percentage.

At certain times of the year huge gelatinous colonies of bryozoans are found along the bottom and occassionally wash up on the beaches (Scholl, 1965). Britt et al. (1973) designates the benthic population as representative of eutrophic but not grossly polluted waters. Table 34 presents a list of the benthic organisms found in the island area.

Turtle Island lies on the outer fringe of Maumee Bay. A study of the Maumee Bay benthos was conducted by Herdendorf and Cooper (1975). The dominant organisms here were also found to be oligochaetes and chironomids with oligochaetes comprising 90% of the total population and chironomids 9.2%. At the station nearest to Turtle Island, some pelecypods (Pisidium sp. and Sphaerium) were found to compose 4% of the sample.

Freshwater mussels occur in small numbers throughout most of the island area, with more extensive populations found in the more sheltered habitats. One such area of concentration is Fishery Bay on the north side of South Bass Island, which has been the site of extensive investigations by Brown, et al. (1938) and Stansbery (1960). Brown et al. (1938) collected 24 species in Fishery Bay and Stansbery (1960) identified 27 species as occurring in the bay. The species around the islands are found predominantly on gravel bars in shallow water. Some freshwater mussels are also found on silt bottoms in deeper water, but they are generally smaller and slower growing than those of gravel bars. The lake mussels appear stunted when compared with their stream counterparts and were formerly thought to be separate species (Stansbery, 1960).

TABLE 34

BENTHIC MACROINVERTEBRATE ORGANISMS OF LAKE ERIE

ANNELIDA
- Hirudinea
  - Helobdella elongata
  - H. stagnalis
  - H. fusca
  - Glossiphonia complanta
  - G. heteroclita
  - Erpobdella punctata
- Polychaeta
- Oligochaeta
  - Aulodrilus limnobius
  - A. pluriseta
  - Branchiura sowerbyi
  - Ilyodrilus templetoni
  - Limnodrilus cervix
  - L. cervix variant
  - L. claperedeianus
  - L. hoffmeisteri
  - L. maumeesis
  - L. spiralis
  - L. udekemianus
  - Peloscolex ferox
  - P. multisetosus
  - Potamothrix moldaviensis
  - P. vejdovskyi
  - Tubifex tubifex
  - Dero digitata

ARTHROPODA
- Crustacae
  - Asellus r. racovitzai
  - Gammarus fasciatus
- Insecta
  - Oecetis sp.
  - Oecetis eddlistoni
  - Chironomus plumosus
  - C. riparius
  - C. (Cryptochironomus) sp.
  - Coelotanypus sp.
  - Procladius sp.
  - Tanypus sp.

MOLLUSCA
- Gastropoda
  - Physa sp.
  - Heliosoma sp.
  - Amnicola sp.
  - Bulimus tentaculata
  - Valvata sincera
  - V. tricarinata
  - Campeloma sp.
  - Goniobasis sp.
  - Somatogyra sp.
- Pelecypoda
  - Ligumia recta
  - Lampsilis radiata luteola
  - Leptodea sp.
  - Pisidium sp.
  - Pisidium compressum
  - Sphaerium sp.

COELENTERATA
- Hydra sp.

PLATYHELMINTHES
- Planaridae
- Rhabodocoela

ECTOPROCTA
- Pectinatella magnifica

Data Source:
Britt et al. (1977)

Terrestrial Invertebrates

Published studies of terrestrial invertebrates from the Lake Erie islands are limited in number. Horwath (1964) compiled a list of insects found on Gibraltar Island. This study related species encountered to habitat. The dominant groups present were Trichoptera, Diptera, Hymenoptera and Coleoptera (Appendix A). It is assumed that these species also occur in similar habitats on the other islands and that many additional species occur on the larger as well as the less developed islands. Kennedy (1922) studied the distribution of dragonfly species encountered in the vicinity of the island wetlands. Table 35 lists the species found and their preferred habitats. A distinct species preference was noted for wetlands in different successional stages, with Put-in-Bay harbor being the most open area and Fox's Pond (marsh) being the most advanced successional area studied.

The distribution of spiders on the Lake Erie islands (Table 36 has been studied intensively by Beatty (1971). This effort has resulted in a CHECKLIST OF SPIDERS OF THE LAKE ERIE ISLANDS which records species, frequency of occurrence, and collection site. This checklist is presented and summarized in Appendix A. Dr. Beatty has collected spiders in the island region annually since 1959. The long term goal of the study is a contribution to the field of island biogeography.

Most publications dealing with the terrestrial mollusks of the islands were prepared forty to fifty years ago--Allen (1915), Clapp (1916), Goodrich (1916) and Ahlstrom (1930). All of these publications describe a large number of snails covering the ground throughout their respective study areas. Duncan (1977) attributes the lack of leaf litter in the island woodlots to the large local snail populations and to extreme weather conditions. Goodrich (1916) indicates that the islands support a number of unique subspecies:

> "We hope at some future date to pay a more leisurely visit to these islands and make a more thorough study of the geology and botany with the idea of getting additional light on their age, as this may indicate how long it takes a species, such as Pyramidula solitaria (Anguispira kochi)-which goes back to inter if not pre-glacial time unchanged from its present typical form- to change to distinct, and strongly marked races, as on the islands."

Taft (1961) records nine species of snail as occurring only in the island area (Table 37). One species, Triodopsis albolabris goodrichi, was found only on South Bass Island and Kelleys Island. Anguispira kochi strontiana is currently confined to Green Island. The land snails known from the island region are listed in Appendix A.

TABLE 35

SUCCESSION OF DRAGONFLY SPECIES
AS ISLAND PONDS DEVELOP AND AGE

TAXA	Open water → Closed Pond								
	Put-in-Bay Harbor	Hatchery Bay	Squaw Harbor	Terwilliger's Pond	Monument Pond	Hanck's Pond	Fischer's Pond	Smith's Pond	Fox's Pond
Gomphus plagiatus	X	X	X						
Gomphus vastus	X	X	X	X					
Neurocordulia yamaskensis	X	X	X	X					
Macroma illinoiensis	X	X	X	X					
Argia moesta	X	X	X	X	X				
Enallagna carunculatum		X	X	X	X	X	X	X	
Enallagna exsulans		X	X	X	X	X	X	X	
Ischnura verticallis		X	X	X	X	X	X	X	X
Enallagna ebrium		X	X	X	X	X	X	X	
Tramea lacerata			X	X	X	X	X	X	
Anax junius			X	X	X	X	X	X	X
Enallagna signatum				X	X	X	X	X	
Libellula pulchella				X	X	X	X	X	X
Libellula luctuosa				X	X	X	X	X	
Lestes rectangularis				X	X	X	X	X	X
Leucorrhinia intacta					X	X	X	X	
Erythemis simplicicollis					X	X	X	X	
Nehalennia irene					X	X	X	X	
Pachydiplex longipennis					X	X	X	X	X
Lestes forcipatus					X	X	X	X	X
Sympetrum obtrusum					X	X	X	X	X
Sympetrum vicinum					X	X	X	X	X
Sympetrum rubicundulum					X	X	X	X	X
Lestes uncatus								X	X
Lestes unquiculatus								X	X

Data Source: Kennedy (1922)

TABLE 36

ABUNDANCE OF SPIDERS ON THE LAKE ERIE ISLANDS

Island	# of Species
South Bass	150
Gibraltar	130
Kelleys	78
North Bass	62
Middle Bass	67
Green	51
Rattlesnake	42
Ballast	25
East Sister	20
West Sister	35
Pelee	76
Sugar	13
Starve	13
large Rattle	6
small Rattle	5
Lost Ballast	12
Big Chicken	6

Data Source: Beatty (1971); Beatty, personal communication (1977)

TABLE 37

LAND SNAILS OF OHIO FOUND ONLY IN THE ISLAND AREA

Allogona profunda strontiana
Anguispira alternata eriensis
A. kochi albina
A. kochi mynesites
A. kochi roseo-apicata
A. kochi strontiana
Mesodon inflectus medius
Succinea higginsi
Triodopsis albolabris goodrichi (only on South Bass and Kelleys)

Data Source: Taft (1961)

Fish

The western basin has long been considered to have the most valuable fish spawning and nursery grounds in the lake and is the site of extensive sport fishing. Ninety-five species of fish have been reported from the lake waters surrounding the islands. These species have differed in abundance and dominance throughout recorded time. When the area was first settled lake sturgeon, cisco, whitefish, blue pike, and walleye were the most important members of the fish community. Dominant species today are perch, bass, channel catfish, alewife, gizzard shad, carp, goldfish, freshwater drum, and emerald shiner (Scholl, 1970).

Hartman (1973) attributes the change in species dominance to the following conditions: 1) an intense, opportunistic, ineffectively controlled commercial fishery, 2) changes in the watershed, such as erosion and siltation of stream beds and inshore lake areas, and construction of dams in tributaries, 3) nutrient loading, destruction of biota, and reduction of dissolved oxygen, and 4) the competitive and predatory activities of invading species. The damming and draining of many tributaries and marshes made spawning grounds inaccessible to the sturgeon and sauger. The decline of the lake sturgeon was also a result of unprecedented killing by fishermen for damage caused to fish nets. Since the sturgeon does not spawn until it is 20 years old, this senseless killing greatly reduced its numbers. Introduced species such as the carp and goldfish have readily established themselves in the western basin. The area is no longer fished commercially to any great extent; almost all fishing is recreational.

Smith, et al. (1973) lists 16 species in the "Rare and Endangered Vertebrates of Ohio" as seen in Table 38. Commercially important fish species and sport fish are given in Tables 39 and 40, respectively. Sauger (S. canadense) were stocked in Sandusky Bay during 1974, 1975, and 1976 by ODNR, Division of Wildlife. A complete table of the Erie island species is found in the Appendix.

Fisheries. The Turtle Island area and Maumee Bay are important spawning and forage areas for many commercially important fish. The species utilizing the bay as a nursery area are, in order of abundance: gizzard shad, freshwater drum, yellow perch and white bass. (Herdendorf and Cooper, 1975).

Adult catches in the bay region are dominated by rough fish species. The gizzard shad was the most abundant rough fish species captured. Other rough fish contributing significantly to the total catch are: alewife, carp, and freshwater drum. Forage fish include spottail shiner and emerald shiner (Herdendorf and Cooper, 1975).

TABLE 38

RARE AND ENDANGERED SPECIES OF THE LAKE ERIE ISLAND REGION

Endangered

BIRDS	
Accipiter striatus velox	Sharp-shinned hawk
Haliaeetus leucocephalus	Bald eagle
Rallus e. elegans	King rail
Sterna h. hirundo	Common tern
FISH	
Acipenser fulvescens	Lake sturgeon
Lepisosteus oculatus	Spotted gar
Hiodon tergisus	Mooneye
Coregonus artedii	Great Lakes cisco
Esox m. masquinongy	Great Lakes muskellunge
Notropis emiliae	Pugnose minnow
Moxostoma valenciennesi	Greater redhorse
Erimyzon sucetta	Lake chubsucker
Lota lota	Burbot
Etheostoma exile	Iowa darter
Percina copelandi	Channel darter
Stizostedion vitreum glaucum	Blue pike

Possibly Endangered

FISH	
Cottus ricei	Spoonhead sculpin
Stizostedion canadense	Sauger

Rare

FISH	
Coregonus clupeaformis	Lake whitefish

Data sources: Smith, et al. (1973); Ohio Department of Natural Resources, Division of Wildlife Publication No. 316 (1976).

TABLE 39

COMMERCIALLY IMPORTANT FISH SPECIES OF THE LAKE ERIE ISLAND REGION

Aplodinotus grunniens	Freshwater drum
Carassius auratus	Goldfish
Catastoma sp. and Moxostoma sp.	Suckers
Cyprinus carpio	Carp
Ictalurus punctatus	Channel Catfish
Ictalurus sp.	Bullheads
Morone chrysops	White Bass
Perca flavescens	Yellow Perch
Stizostedion vitreum vitreum	Walleye

Data Source: Ohio Department of Natural Resources, Div. Wildlife (1975)

TABLE 40

SPORT FISH SPECIES OF THE LAKE ERIE ISLAND REGION

Ambloplites rupestris	Rock bass
Esox lucius	Northern pike
Esox masquinongy	Muskellunge
Ictalurus punctatus	Channel catfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Morone chrysops	White bass
Oncorhyncus kisutch	Coho salmon
Perca flavescens	Yellow perch
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
Stizostedion canadense	Sauger
Stizostedion vitreum vitreum	Walleye

Data Source: Ohio Department of Natural Resources, Div. Wildlife (1975)

Important commercial and sport fish in the bay area include: walleye, yellow perch, white bass, and channel catfish (Herdendorf and Cooper, 1975). The fish community structure of Maumee Bay as revealed by gill net sampling in the spring of 1974 is shown in Figure 33.

To determine if environmental conditions in Maumee Bay excluded any fish, Fraleigh, et al. (1975) surveyed Scott and Crossman (1973) to develop a list of species that would be expected in the spring in the bay based on the present species in Lake Erie (Table 41). The only species on the list not found in sampling by Fraleigh, et al. was the mooneye (Hiodon tergisus). However, during 1975 several specimens of larval mooneye were taken with an ichthyoplankton net in the north bay area near Turtle Island (Herdendorf and Cooper, 1975). This indicates that Maumee Bay is a relatively healthy ecosystem in terms of the fisheries found there.

TABLE 41

ECOLOGICAL AND ECONOMIC IMPORTANCE OF FISHES CAUGHT IN MAUMEE BAY IN THE SPRING OF 1974

Fish	Spawning		Adult Feeding Niche	Importance to Man
	Habitat	Time		
Walleye Stizostedion vitreum (Mitchill)	rocky shoals in lakes and rivers	Spring (6-11°C) pre-spawn migration 1.1°C	fish predator	perhaps the most important commercial and sport fish in Lake Erie
White bass Morone chrysops (Rafinesque)	rocky shoals in lakes and rivers	Spring (12-20°C)	fish predator	important commercial and sport fish
Yellow perch Perca flavescens (Mitchill)	weedy shallows or sand and gravel	Spring (8-13°C)	fish and bottom	important commercial fish and a food fish for Walleye
Freshwater drum Aplodinotus grunniens Rafinesque	over mud or sand bottom in shallow water	Summer (20+)	bottom and some fish	commercial fish and a food fish for Walleye
Carp Cyprinus carpio Linnaeus	weedy or grassy shallows	Spring (17-26°C)	benthic omnivore	environmentally a destructive pest species but also a commercial fish
Goldfish Carassius auratus (Linnaeus)	warm, weedy shallows	Late Spring	benthic omnivore	little to no value
Channel catfish Ictalurus punctatus (Rafinesque)	in dark nests in holes, log jams in shallow area of turbid waters	Summer (24-30°C)	bottom	commercial fish
White sucker Catostomus commersoni (Lacepede)	quiet, gravel shallows of lakes and rivers	Spring (10°C)	benthic omnivore	minor commercial; fish when abundant a major food item for predatory fish
Quillback Carpiodes cyprinus (Lesueur)	shallow quiet, mud or sand areas of lakes and rivers	Late Spring	benthic omnivore	of little value either directly to man or in the food chain to important species

TABLE 41 -continued
ECOLOGICAL AND ECONOMIC IMPORTANCE OF FISHES
CAUGHT IN MAUMEE BAY IN THE SPRING OF 1974

Fish	Spawning Habitat	Spawning Time	Adult Feeding Niche	Importance to Man
Gizzard shad *Dorosoma cepedianum* (Lesueur)	probably over sand or gravel bottom	Late spring to summer	phytoplankton feeders	Small gizzard shad are an important forage fish for game and commercial species.
Alewife *Alosa pseudoharengus* (Wilson)	shallow beaches, ponds and quiet rivers	Spring	zooplankton feeders	Generally considered a nuisance due to annual die-offs but can be an important forage fish for game and commercial species.
Rainbow trout *Salmo gairdneri* Richardson	fine gravel in a riffle above a pool, in a small stream or outlet of such a stream	Spring	predator on fish	one of the top five sport fish in North America
Northern pike *Esox lucius* Linnaeus	in weedy flood plains of rivers and in marshes and weedy bays	Early Spring	fish predator	important but rare commercial and sport fish
Mooneye *Hiodon tergisus* Lesueur	pools in turbid rivers, backwater lakes and ponds	Late spring to early summer	omnivore	minor commercial and sport fish
Emerald shiner *Notropis atherinoides* Rafinesque	midwater	Late spring to summer	plankton	major food item for several sport fish; used as bait minnow by man
Spottail shiner *Notropis hudsonius* (Clinton)	over sandy shoals	Spring and early summer	omnivore	an important forage fish; used as bait minnow by man
Logperch *Percina caprodes* (Rafinesque)	sandy inshore shallows	Late spring	benthic carnivore	unknown importance as forage fish for game and commercial species

Data Source: Fraleigh, et al. (1975); Scott and Crossman (1973)

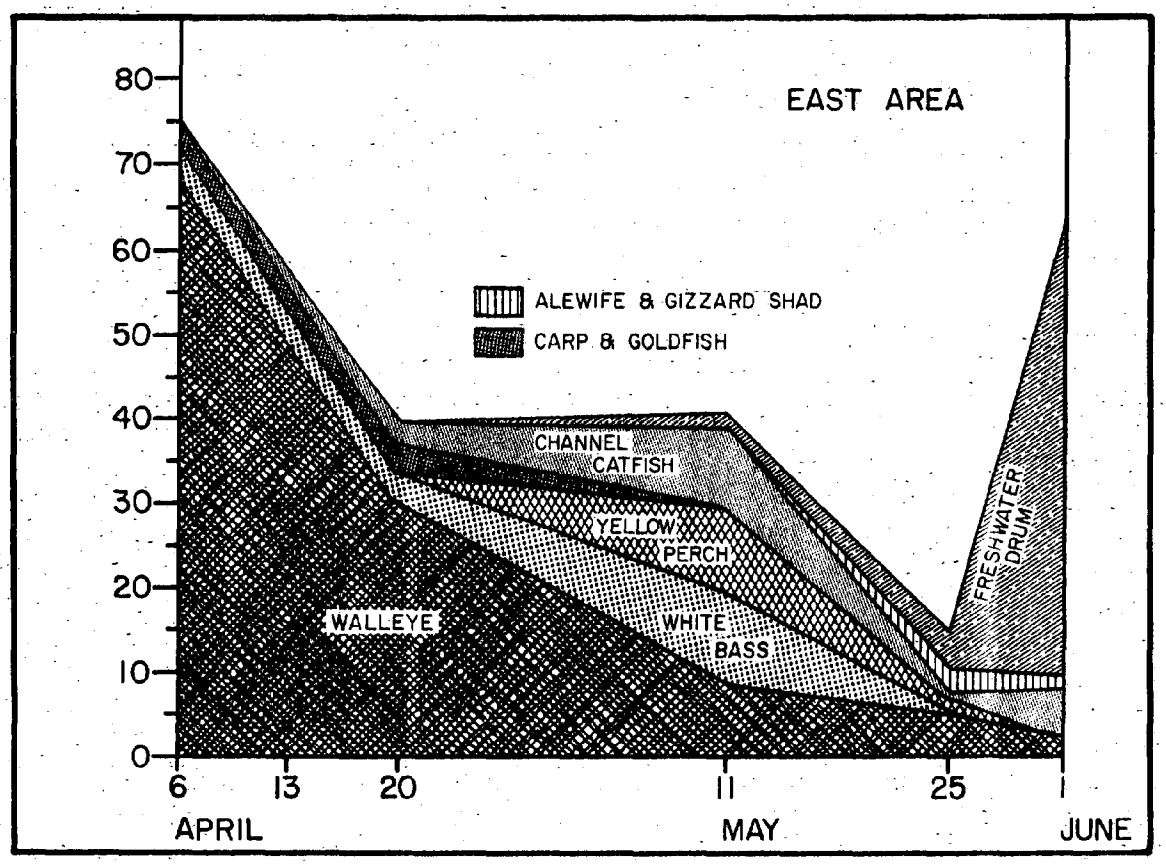


FIGURE 33. NUMBER OF FISH CAPTURED WITH GILL NETS IN THE EASTERN PART OF MAUMEE BAY, SPRING 1974 (FRALEIGH, ET AL., 1975)

Amphibians and Reptiles

The amphibians and reptiles of the island fauna are found in the open lakes, ponds, marshes, caves, along the shore, and on dry-land. The mudpuppy is fairly common in the open water, burrowing into the muddy bottom. Several species of salamanders, frogs, toads, and newts are found in a variety of habitats.

At one time the islands supported a dense population of snakes. Many journals of early explorers and settlers tell of such great numbers of rattlesnakes that one could practically tread on one with every step. After years of being slaughtered on sight and hunted by herds of hogs shipped to the islands, the timber rattlesnake has not been sighted since 1951 and has probably been extirpated (Langlois, 1964). Also mentioned was a "hissing snake" which was said to blow a nauseous wind upon its victim that could prove fatal if inhaled. This snake has been compared to the common water snakes (Natrix sipedon) of the area which bite viciously when attacked and secrete a foul smelling substance from musk glands as a defense mechanism (Frohman, 1971). The inland water snake (Natrix sipedon insularum) remains fairly common around the islands, particularly the uninhabited ones, and can be seen swimming along the shore with its head above water or sunning on the flat rocks or vegetation near the water's edge. In contrast to the distinctly banded pattern of the northern water snake (N.s. sipedon), large specimens of the Lake Erie water snake are usually a uniform green-brown pattern. The shift towards unbanded pattern types on the islands has been attributed to strong post-natal selection, demonstrable without regard to selective agent (Camin and Ehrlich, 1958).

Populations of rare triploid salamanders of the genus Ambystoma sp. exist on Kelleys, Middle Bass, and North Bass Island. The North Bass Island population is particularly unique in that hybrid individuals occur. This complex population is fairly well established in the vicinity of Fox's Marsh and is rarely disturbed. Ambystoma sp. and A. texanum occur in the wetlands of Middle Bass. The Middle Bass Island populations are threatened by habitat destruction. These populations have been under study for several years by Dr. Floyd Downs of Wooster College.

A list of the amphibians and reptiles and their habitats recorded for the islands appears in Table 42. A complete list by island is given in Appendix A.

TABLE 42

AMPHIBIANS AND REPTILES OF THE LAKE ERIE ISLANDS [1]

SPECIES (Common Name)	HABITAT					
	Lake	Pond	Shore	Marsh	Cave	Terrestrial
Necturus m. maculosus (mudpuppy)	×					
Ambystoma jeffersonianum (Jefferson salamander)			×			
Ambystoma maculatum (spotted salamander)						×
Ambystoma texanum (small-mouth salamander)		×				
Ambystoma t. tigrinum (eastern tiger salamander)		×				
Diemictylus v. viridescens [3] (red-spotted newt)		×		×		
Plethodon c. cinereus (red-backed salamander)					×	
Bufo a. americanus (American toad)						×
Rana catesbeiana (bullfrog)		×				
Rana p. pipiens (northern leopard frog)				×		
Chelydra s. serpentina [4] (common snapping turtle)				×		
Emydoidea blandingi (Blanding's turtle)				×		
Graptemys geographica (map turtle)	×					
Graptemys picta marginata (midland painted turtle)	×					
Natrix kirtlandi (Kirtland's water snake)	×					
Natrix s. sipedon (northern water snake)	×					
Natrix sipedon insularum (Lake Erie water snake)	×					
Storeria d. dekayi (northern brown snake)			×			
Thamnophis s. sirtalis (eastern garter snake)						×
Heterodon contortrix (hog-nose snake)						×
Diadophis punctatus edwardsii (northern ringneck snake)						×
Coluber c. constrictor (black racer)						×
Coluber constrictor flaiventris * (eastern yellow-bellied racer)						×
Coluber constrictor foxi (blue racer)						×
Elaphe vulpina gloydi (eastern fox snake)						×
Elaphe o. obsoleta (black rat snake)						×
Crotalus h. horridus * (timber rattlesnake)					×	×

[1] After Langlois (1964).

* Formerly present; current status uncertain, probably absent

Birds

The islands in western Lake Erie have a wide variety of birds and waterfowl. These fall into four categories: permanent residents, winter visitors (most often found only in winter), half-hardy birds (transients or summer residents which sometimes stay through the winter), and accidental visitors (Table 43). Bird watching is a popular sport on the islands for visitors and islanders alike.

A rookery of black-crowned night herons, common egrets, great blue herons, and green herons exists on West Sister Island which is a National Wildlife Refuge. Thousands of birds nest here every year, occupying nearly every available space. With such a concentrated population in this small area, the birds are forced to go great distances to feed and are seen feeding in the mainland marshes and around the other islands. An occasional nest will be found on the other islands, particularily the uninhabited ones, but never to the extent of the colonies on West Sister.

Rocky, largely barren Starve Island was a favorite nesting site for common terns until they were crowded out by the herring gulls. Ligas (1952) reported that 1052 tern nests were counted in 1939, but in 1964 the island was reported to be completely taken over by the herring gulls (Langlois, 1964). It is interesting to note that in 1926 there was only one herring gull nest on Starve Island and no record of herring gulls nesting anywhere along the Ohio shoreline (Shipman, 1927). Other favored nesting sites include the Rattles off Rattlesnake Island, Lost Ballast, and several rock outcroppings occurring around the islands. The nearby Canadian islands are also popular nesting areas for herons, gulls, egrets, and cormorants. An occasional tern can be seen amid the flocks of gulls following the ferry boats, but their numbers have been drastically reduced since the arrival of the herring gulls. Critical nesting and migration areas are given in Table 44.

In 1921 the ring-necked pheasant was stocked on South Bass Island by the Ohio Division of Fish and Game (Langlois, unpublished manuscript). They multiplied and have become a nuisance to the farmers and grape growers, but are a great attraction for hunters in late fall. The other islands also support a fairly large pheasant population and together with the northern marshes in the state represent the only sites of any significant numbers of ring-necked pheasants remaining in Ohio (Trautman and Trautman, 1968). Rattlesnake Island was stocked with golden pheasants and wild turkeys about thirty years ago (Ross, 1949), but neither remain today although the ring-necked pheasant is still common.

As defined in "Rare and Endangered Vertebrates of Ohio"

(Smith, et. al., 1973) no endangered species nests on the islands (Table 38). Several years ago single nests of the northern bald eagle were located on South Bass, Green, Kelleys, Rattlesnake, and West Sister Islands, but today there are no known active nests on the islands. The following species found in the area are considered to be rare by Smith, et al. (1973): common egret, least bittern, hooded merganser, king rail, common tern, and orchard oriole. Ten species common to the islands are listed as being of undetermined status due to noticeable decreases in populations in recent years and bear further surveillance. These species include: pied-billed grebe, American bittern, ring-necked pheasant, common gallinule, black tern, purple martin, crow, warbling vireo, baltimore oriole, and rough-winged swallow.

A list of birds reported for each island appears in the Appendix.

TABLE 43

BIRDS OF THE LAKE ERIE ISLANDS

Permanent	
Anas rubripes	Common black duck
Haliaetus leucocephalus alascanus	Northern bald eagle
Phasianus colchicus torquatus	Ring-necked pheasant
Larus argentatus	Herring gull
Otus asio	Eastern screech owl
Dendrocopus pubescens	Northern downy woodpecker
Corvus brachyrhynchos	Common crow
Thyothorus indovicianus	Carolina wren
Bombycilla cedrorum	Cedar waxwing
Sturnus vulgaris vulgaris	Starling
Passer domesticus domesticus	House sparrow
Richmondena cardinalis	Cardinal
Melopiza melosia	Song sparrow
Winter	
Glaucionetta clangula americana	Common goldeneye
Larus marinus	Great black-backed gull
Nyctea scandiaca	Snowy owl
Cyanocitta cristata	Blue jay
Parus atricapillus	Black-capped chickadee
Sitta carolinensis	White-breasted nuthatch
Certhia familiaris	Brown creeper
Regulus satrapa satrapa	Golden-crowned kinglet
Hesperiphona vespertina vespertina	Evening grosbeak
Carpodacus purpureus purpureus	Purple finch
Junco hyemalis	Slate-colored junco
Spizella arborea arborea	Tree sparrow
Half Hardy (Transients or summer residents)	
Gavia immer	Common loon
Colymbus auritus	Horned grebe
Podilymbus podiceps podiceps	Pied-billed grebe
Phalacrocorax auritus	Double-creasted cormorant
Ardea herodias	Great blue heron
Casmerodius albus egretta	Common egret
Butorides virescens virescens	Green heron
Nycticorax nycticorax	Black-crowned night heron
Botaurus lentiginosus	American bittern
Ixobrychus exilis exilis	Least bittern
Olor columbianus	Whistling swan

TABLE 43 (Con't)

BIRDS OF THE LAKE ERIE ISLANDS

Half Hardy (Continued)	
Branta canadensis	Canada goose
Chen hyperborea	Snow goose
Chen caerulescens	Blue goose
Anas platyrhynchos platyrhynchos	Mallard
Aix sponsa	Wood duck
Aythya americana	Redhead
Aythya collaris	Ring-necked duck
Aythya valisineria	Canvas-back
Aythya affinis	Lesser scaup duck
Glaucionetta albeola	Buffle-head
Anas discors	Blue-winged teal
Mareca americana	Bald pate
Spatula clypeata	Shoveller
Melanitta perspicillata	Surf scoter
Lophodytes cucullatus	Hooded merganser
Mergus merganser americanus	Common merganser
Mergus serrator	Red-breasted merganser
Cathartes aura	Turkey vulture
Accipiter striatus velox	Sharp-shinned hawk
Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
Buteo platypterus platypterus	Broad-winged hawk
Buteo lagopus	Rough-legged hawk
Circus cyaneus hudsonius	Marsh hawk
Pandion haliaetus carolinensis	Osprey
Falco sparverius	Sparrow hawk
Rallus elegans elegans	King rail
Rallus limicola limicola	Virginia rail
Porzana carolina	Sora rail
Gullinula chloropus cachinnans	Common gallinule
Fulica americana	American coot
Charadrius alexandrinus tenuirostris	Semipalmated plover
Charadrius vociferus vociferus	Killdeer
Squatarola squatrola	Black-bellied plover
Arenaria interpers morinella	Ruddy turnstone
Philohela minor	Woodcock
Capella gallinago delicata	Common snipe
Numenius phaeopus hudsonicus	Hudsonian curlew
Actitus macularia	Spotted sandpiper

TABLE 43 (Con't)

BIRDS OF THE LAKE ERIE ISLANDS

Half Hardy (Continued)	
Tringa solitaria solitaria	Solitary sandpiper
Catoptrophorus semipalmatus	Willet
Totanus melanoleucus	Greater yellowlegs
Totanus flavipes	Lesser yellowlegs
Calidris canutus rufus	Knot
Erolia maritima	Purple sandpiper
Erolia minutilla	Least sandpiper
Limnodromus griseus	Dowitcher
Ereunetes pusillus	Semipalmated sandpiper
Crocethia alba	Sanderling
Steganopus tricolor	Wilson's phalarope
Larus delawarensis	Ring-billed gull
Larus philadelphia	Bonaparte's gull
Sterna hirundo hirundo	Common tern
Hydroprogne caspia	Caspian tern
Chlidonias nigra surinamensis	Black tern
Zenaidura macroura	Mourning dove
Coccyzus americanus americanus	Yellow-billed cuckoo
Coccyzus erythrophthalmus	Black-billed cuckoo
Tyto alba pratincola	Barn owl
Aegolius acadica acadica	Saw-whet owl
Caprimulgus vociferus	Whip-poor-will
Chordeiles minor	Common night hawk
Chaetura pelagica	Chimney swift
Archilochus colubris	Ruby-throated hummingbird
Megaceryle alcyon alcyon	Belted kingfisher
Colaptes aurates	Yellow-shafted flicker
Centurus carolinus	Red-bellied woodpecker
Melanerpes e. erythrocephalus	Red-headed woodpecker
Sphyrapicus varius varius	Yellow-bellied sapsucker
Tyrannus tyrannus	Kingbird
Myiarchus crinitus	Great-crested flycatcher
Sayornis phoebe	Phoebe
Empidonax flaviventris	Yellow-bellied flycatcher
Empidonax trailli trailli	Alder flycatcher
Empidonax minimus	Least flycatcher
Contopus virens	Wood pewee
Eremophila alpestris alpestris	Northern horned lark
Eremophila alpestris practicola	Prairie horned lark
Iridoprocne bicolor	Tree swallow

TABLE 43(Con't)

BIRDS OF THE LAKE ERIE ISLANDS

Half Hardy (Continued)	
Stelgidopteryx ruficollis serripennis	Rough-winged swallow
Hirundo rustica erythrogaster	Barn swallow
Progne subris subris	Purple martin
Parus carolinensis	Carolina chickadee
Parus bicolor	Tufted titmouse
Troglodytes troglodytes hiemalis	Eastern house wren
Troglodytes bewickii	Bewick's wren
Telmatodytes palustris	Long-billed marsh wren
Cistothorus platensis stellaris	Short-billed marsh wren
Dumetella carolinensis	Catbird
Toxostoma rufum rufum	Brown Thrasher
Turdus migratorius	Robin
Hylocichla mustelina	Wood thrush
Hylocichla guttata faxoni	Eastern hermit thrush
Hylocichla ustalata swainsonii	Swainson's thrush
Hylocichla minima	Gray-cheeked thrush
Hylocichla fuscescens	Veery
Sialia sialis	Eastern bluebird
Polioptila caerulea caerulea	Blue-gray gnatcatcher
Regulus calendula calendula	Ruby-crowned kinglet
Anthus spinoletta rubescens	American water pipet
Lanius excubitor borealis	Northern shrike
Vireo solitarius	Solitary vireo
Vireo olivaceus	Red-eyed vireo
Vireo philadelphicus	Philadelphia vireo
Vireo gilvus gilvus	Warbling vireo
Dendroica petechia	Yellow warbler
Seiurus aurocapillus	Ovenbird
Geothlypis trichas brachidactyla	Northern yellow-throat
Setophaga ruticilla	American redstart
Species Unknown	Warbler
Dolichonyx oryzivorus	Bobolink
Sturnella magna	Eastern meadowlark
Agelaius phoeniceus	Red-winged blackbird
Icterus spurius	Orchard oriole
Icterus galbula	Baltimore oriole
Quiscalus quiscula versicolor	Common grackle
Molothrus ater ater	Brown-headed cowbird
Piranga olivacea	Scarlet tanager
Pheucticus ludovicianus	Rose-breasted grosbeak

TABLE 43 (Con't)

BIRDS OF THE LAKE ERIE ISLANDS

Half Hardy (Continued)	
Passerina cyanea	Indigo bunting
Spinus pinus pinus	Pine siskin
Spinus tristis tristis	American goldfinch
Loxia leucoptera leucoptera	White-winged crossbill
Pipilo erthrophthalmus	Eastern towhee
Passerculus sandwichensis	Savannah sparrow
Amodramus savannarum	Grasshopper sparrow
Passerherbulus henslowii	Henlow's sparrow
Poaecetes gramineus gramineus	Vesper sparrow
Junco oreganus	Oregon junco
Spizella passerina passerina	Chipping sparrow
Spizella pusilla pusilla	Field sparrow
Zonotrichia leucophrys	White-crowned sparrow
Plectrophenax nivalis nivalis	Snow bunting
Accidental Visitors	
Colymbus nigricollis californicus	Eared grebe
Plegadis falcinellus falcinellus	Glossy ibis
Stercorarius parasiticus	Parasitic Jaeger
Uria lomvia lomvia	Thick-billed murre
Seiurus motacilla	Louisiana waterthrush

Data Sources:

Langlois and Langlois (1964a)
Trautman and Trautman (1968)

TABLE 44

CRITICAL BIRD NESTING AND MIGRATION AREAS[1]

ISLAND	NESTING AREAS	MIGRATION AREAS	REMARKS
West Sister	great blue heron, green heron, black-crowned night heron, common egret	-	100 nesting egrets
Catawba			
East Harbor	-	waterfowl	
West Harbor	-	-	
Middle Harbor	-	-	Resting area for migrating waterfowl
Starve	herring gull	-	
Green	herring gull	passerine	
South Bass	black-crowned night heron	passerine	Cedar roost west of Put-in-Bay, owned by Heineman's Winery, is major stopover for blackbirds.
North Bass	black-crowned night heron, waterfowl	waterfowl, shorebirds	Major blackbird, robin, and blue jay flights stopover here from Point Pelee.
Ballast	herring gull, ring-billed gull	-	
Gull Island Shoal	herring gull	-	Only during low water years.
Kelleys	waterfowl	waterfowl, passerine	Marsh nearly filled in.

TABLE 44(Continued)

CRITICAL BIRD NESTING AND MIGRATION AREAS

ISLAND	NESTING AREAS	MIGRATION AREAS	REMARKS
Middle Sister	blue heron, herring gull	-	
East Sister	blue heron, black-crowned night heron, common egret, herring gull	-	
Big Chicken	herring gull, double-crested coromorant	-	
Hen	herring gull	-	
Pelee	herring gull, blue heron, black-crowned night heron	passerine	

[1] Appendix 12: Shore Use and Erosion, Great Lakes Basin Framework Study. GLBC. (1975).

Mammals

The species diversity of mammals inhabiting the islands is understandably low considering their isolation from the mainland and the small area involved. Only thirteen species have been recorded as being permanent residents and these are all small animals. Raccoon, red fox, and muskrat occur in small numbers due to lack of suitable habitat.

Several species of mice exist, usually in areas of human population (Fall et al, 1968). The Norway rat is particularly dependent upon human habitation as its main center of repopulation is the dump. An exotic population of the eastern woodrat is found on Gibraltar Island. It is known in Ohio only in the southern portion of the state. It is suggested that a pregnant female arrived with a shipment of equipment delivered to the F.T. Stone Laboratory on the island, and the population became established in 1973 when the lab was relatively unoccupied (CLEAR, 1974). Its continued existence on Gibraltar Island is unconfirmed.

A campaign to eliminate the high number of rats on South Bass Island by poisoning in 1952 severely depleted the population of eastern gray squirrels. Concerned islanders imported several black squirrels from Belle Isle Park in Detroit to help reverse this situation (Langlois, unpublished manuscript). The two species interbred to the extent that the only squirrels present today are melanistic eastern gray squirrels. The cottontail rabbit accounts for a large percentage of the mammal population of the islands.

The little brown bat is a permanent resident of the islands, but its secretive nature prevents it from being obvious. It remains dormant throughout the winter and is able to withstand extreme cold temperatures. Empty cottages, boathouses, sheds, barns and caves provide an abundance of sites suitable for habitation.

A herd of African Mountain sheep roam wild on Rattlesnake Island where they were introduced a number of years ago (Faris, 1976). During the severe winter of 1976-1977 the herd was reduced from nine to three (Larry Wilson, personal communication).

A small number of deer live in the remaining wild areas of Catawba Island and the adjacent Marblehead Peninsula. During cold winters when the lake freezes over they occasionally cross the ice to some of the islands. Several were sighted on Kelleys Island in December, 1976 soon after the ice had formed (Schutte, personal communication). A list of mammals presently occupying the islands is found in Table 45.

TABLE 45

MAMMALS OF THE LAKE ERIE ISLANDS

Blarina brevicauda (short-tailed shrew)
Microtus pennsylvanicus (meadow vole)
Mus musculus (house mouse)
Myotis lucifugus (little brown bat)
Neotoma floridana (eastern woodrat)*
Ondatra zibethica (muskrat)
Peromyscus leucopus (white -footed mouse)
Peromyscus maniculatus bairdii (deer mouse)
Procyon lotor (raccoon)
Rattus norvegicus (Norway rat)
Sciurus carolinensis (eastern gray squirrel)
Sylvilagus floridanus (cottontail rabbit)
Vulpes fulva (red fox)

Data Sources: Fall, et al. (1968)
CLEAR (1974)
Langlois (unpublished manuscript)

* Unpublished, probably nonextant

HISTORY OF THE LAKE ERIE ISLAND REGION

Historical Background

Due largely to use of the Ottawa River system across Canada as a route between the St. Lawrence River and the upper lakes and the ferocity of the Iroquois Indians occupying the territory to the south, Lake Erie was the last of the Great Lakes to be discovered by European man. The Frenchman Louis Jolliet is the first to have recorded seeing Lake Erie in 1669. In 1679, on a trip across the lake aboard the Griffin, the famous explorer Robert de LaSalle stopped at Middle Bass Island where Father Louis Hennepin celebrated the first Catholic mass in the midwest. This was also the first recorded visit by white man to the islands.

The succession of ownership and habitation of the islands is rather confusing due to conflicting reports and lack of accurate records. Reports show the land to be simultaneously claimed by the French, British, Americans (including several states), and the Indians. After the War of 1812 there was still some confusion as to which islands were Canadian and which were American. A commission established by the Treaty of Ghent determined ownership of the islands as follows: Middle, Pelee, Hen and Chickens, East and Middle Sister, and North Harbor - Canadian; South Bass, Middle Bass, North Bass, West Sister, Kelleys, Sugar, Green, Ballast, Rattlesnake, and Gibraltar - American. A definitive boundary was not set until 1913 when the International Waterways Commission established the boundary as a series of straight lines determined in reference to fixed objects on the islands.

Archeological excavations on Kelleys Island indicate occupation as early as 3000 B.C. (Behnke et al, 1974). Inscription Rock tells the story of the Erie Indians, after whom the lake was named, and pictures the final annihilation of the tribe by the Iroquois. It is thought that none of the other islands served as permanent residences for any Indian tribe, rather they were used for hunting grounds and resting points for travel across the lake. The Ottawa Indians frequented the area until 1831 and are the subject and source of many legends about Catawba Island.

A large part of northern Ohio and Pennsylvania was granted to Connecticut in 1662 by Charles II of England. All but 3,000,000 acres along the lakeshore, the Western Reserve, were relinquished in 1786 when Congress designated the Northwest Territory (Hatcher,

1945). In 1793 Connecticut deeded 500,000 acres of the Western Reserve to the people who had been burned out during the Revolutionary War and it became known as the Firelands. Another tract of the Western Reserve, including most of the islands, was sold to the Connecticut Land Company. South Bass, Middle Bass, Gibraltar, Sugar, Ballast, Green and Starve Islands fell to the lot of stockholder Pierpont Edwards. The heirs of Edwards began lumbering on the islands and clearing land for agriculture. In 1854, Jose Rivera St. Jurgo[1] bought the islands, surveyed and sold parcels of land, and actually began the establishment of a community on South Bass Island (Stuckey and Duncan, 1977).

After Ohio gained statehood in 1803 and the Fort Industry Treaty of 1805 rescinded all Indian claims to the south shore of Lake Erie, settlement of the northern part of the state accelerated and Ottawa County was organized in 1840. Permanent settlement on the islands did not occur until the mid 19th century.

South Bass Island

South Bass is the most widely known of the islands due to the military exploits of Commodore Oliver H. Perry in the war of 1812. A monument commemorating his famous victory was dedicated in 1931 and declared a national peace memorial in 1935 (Frohman, 1971a).

The earliest known use of the island was as a hunting ground and stopover for journeys across the lake by the Indians. Records as early as 1776 show the island frequented by French traders to collect furs, hides, beeswax and honey, and French squatters were living here when Pierpont Edwards became the owner in 1807. Agents for the Edwards family attempted to raise wheat and flocks of sheep, but the most profitable venture was lumbering. Firewood was in great demand by the steamships on the lake, and the abundance of the supply coupled with the protection offered by Put-in-Bay Harbor made it an ideal fueling station. Much of the high quality lumber was also sent to the mainland cities for shipbuilding (Hudgins, 1943).

In 1854 the island was purchased by Rivera whose main priority was development of the islands. He encouraged settlement on South Bass by having the land surveyed and divided into parcels which he sold to the early inhabitants. Rivera's first venture was raising sheep for which the rocky, cutover land seemed well suited. Seeing

1 Jose Rivera St. Jurgo is referred to by the name Rivera throughout this text.

the success of viniculture on North Bass, Middle Bass and Kelleys Islands, Rivera was instrumental in influencing German immigrants to come to South Bass and plant vineyards. By 1858 the vineyards were well established and several wineries were in operation. Viniculture flourished in the late 1800's but gradually declined under the influence of Prohibition, mainland competition, erosion and depletion of the soil. Only one winery remains in operation on the island today and only a fraction of the former acreage is cultivated as vineyards.

The late 1800's were also peak years for the resort industry. People would flock to the island on the large excursion steamships of the period and the island saw a succession of grand hotels catering to affluent society. The most famous of the island hotels was the elegantly furnished Victory Hotel boasting a capacity of 600 guest rooms and dining space for 2000. It was surrounded by spacious wooded gardens landscaped with native limestone, elaborate statues and fountains, pavilions and a large swimming pool. An electric railway line ran from the hotel to the Bay (business district). The original intention of the owner was to establish the hotel as a convention center, but this dream was never realized and the hotel was only open erratically for the 27 years it existed. Although opened in 1892, it was not completely finished until 1896. The hotel closed in 1909 due to financial difficulties, but was remodeled and reopened for the summer season in 1919. In August of that year a disastrous fire completely destroyed the ill-fated hotel (Frohman, 1971a). Ruins of the famous hotel can still be seen in the state park on the island's west shore. Most of the other large hotels also fell victim to devastating fires or were demolished after years of disuse.

The village of Put-in-Bay was incorporated on the island in 1877, and the name Put-in-Bay is commonly used to refer to the whole island. The Inter Lake Yachting Association has held an annual regatta here since 1884 and prompted the organization of the Put-in-Bay Yacht Club in 1886 (Dodge, 1975).

In 1889 the federal government built a fish hatchery on Peach Point on 0.60 acres of land purchased from Rivera. The State of Ohio built a hatchery adjacent to the federal building in 1907. The state building burned to the ground in 1914 and was replaced with the brick building housing the present hatchery. The federal hatchery discontinued operations in the mid 1930's and the facilities were transferred to the state. With the development of Gibraltar Island as a biological field

station by Ohio State University, the old federal hatchery was converted to laboratory space for researchers and is so used today.

Peach Point was also the site of the Forest City Ice Company which had several large warehouses at the end of the point in the late 1800's and early 1900's. During winters of thick, clear ice, fields were laid out and blocks cut and hauled into the warehouse for storage.

Still a popular summer retreat, the visitors are no longer primarily from high society. Many summer cottages are located on the island, particularly along the west shore. The island is serviced by two ferry lines and an airline, and has accommodations for private boats and airplanes. Several histories of South Bass Island have been written by Langlois and Langlois (1948), Frohman (1971), and Dodge (1975) which describe in great detail life on the island, cultural background, and historic events.

Middle Bass Island

Middle Bass has the distinction of being the site of white man's first recorded visit to the islands. Robert de LaSalle stopped at the island on a trip across the lake aboard the Griffin in 1679, and the first Catholic service in the midwest was celebrated by Father Louis Hennepin. The Frenchmen were so enchanted by the abundance and beauty of the natural flora that they named the island Isle des Fleur, Island of Flowers.

Middle Bass Island fell to the lot of Pierpont Edwards in a draft of the Connecticut Land Company, and agents for the Edwards family lumbered the island. In 1854 it was sold to Rivera who sold it to three Germans: Count William Rehburg, Andrew Wehrle, and a Mr. Caldwell. Finding the island soils and climate ideal for vineyards, they planted grape vines and induced other German immigrants to do the same. The island was soon covered with vineyards and in 1884 the imposing Lonz's Winery was built on the south shore (Ross, 1949).

In the 1870's a group of Toledoans organized the "Lake Erie Boating and Fishing Association" and built a club at Ten Mile Creek near Maumee Bay. The group fished regularly off Middle Bass and soon decided the island would make a better location for their organi-

zation. In 1880 the group leased land from Count Rehburg and built a clubhouse, private cottages, dance hall, boat houses, a central dining area and a small chapel and became known as the Middle Bass Club. Membership was limited to 200 and included Toledo socialites and prominent citizens of the period (Frohman, 1973). Presidents Hayes, Garfield, Arthur, Cleveland, Benjamin Harrison and Taft all spent time here and Taft later built a summer home on the island (Ross, 1949).

For years viniculture and wine-making were the only industries on the island, and when Lonz's Winery became prominent many tourists began to frequent the area promoting a resort business. Some cottages are rented and private summer homes are utilized, but with the recent closing of the Winery the tourist trade has declined.

North Bass Island

Reminiscent of the French influence when North Bass Island was crossed by the international boundary between Canada and the United States, the island was called Isle St. George for many years and is still so listed by the post office. An official concrete international boundary was not fixed until 1913, placing North Bass entirely in the United States (Frohman, 1971a).

The first court records showing island ownership were filed in 1840 with the sale of the island to Horace Kelley (of the Kelleys Island family) by Mrs. Abigail Dumming. In 1853 Simon and Peter Fox bought 500 acres and, inspired by the number of wild grape vines covering the island, planted grapes. Within two years the island was covered with vineyards (Ross, 1949). Roswell Nichols was the first permanent settler, moving to the island in 1844 (Core, 1948).

The vineyard industry peaked in 1890 and steamers stopped there regularly to carry grapes and wine to mainland cities. Today over half the island is owned by Meiers Wine Cellars, Inc. of Silverton, Ohio and cultivated as vineyards. North Bass Island is serviced by Island Airlines, but no ferries stop at the island as there is no resort development.

Kelleys Island

Kelleys Island has more evidence of early occupation by the Indians than any of the other islands. Artifacts have been unearthed indicating settlement as early as 3000 B.C. (Behnke et al, 1974). Indian village sites dating back to the 1600's have been discovered and one of the best examples of American Indian petroglyphic art is located on the south shore. Known as Inscription Rock, the petroglyph was found by Charles Olmstead in 1833. The strange carvings on the rock have been translated as the history of the Erie Indians and their final slaughter in 1655 by the Iroquois (Fisher, 1922).

In the early 1800's the island was known as Cunningham's Island after a French Canadian fur trader living there. After the War of 1812 several families moved to the island, selling the red cedar which covered the island to passing steamers for firewood. Kelleys was so extensively lumbered that by the 1820's it had practically been stripped of woody vegetation.

Datus and Irad Kelley bought the island in 1833 and it has since been known as Kelleys Island. They formed the Kelleys Island Lime and Transport Company in 1886, quarrying limestone for building materials, lime, and crushed stone. Besides the many local buildings the limestone was used in construction of churches in Detroit, office buildings in Cleveland, and the Poe Lock at the Soo (Ross, 1949). Gradually, the industry began to decline and finally shut down in 1941 being unable to compete with more conveniently located quarries on the mainland. Only the abandoned lime kilns, loading docks, and quarries remain as evidence of the once profitable industry.

In the process of quarrying, impressive glacial grooves were uncovered along the north shore. Some of the deepest grooves were removed before their historical significance was realized, but a number of them have been preserved and are now under state protection. They are located on the north shore near the state park public beach.

As on the other inhabited islands viniculture also flourished on Kelleys, but it was never as economically important as the quarries. Seven hundred acres of grapes were cultivated from 1850 to the early 1900's, but under pressures from Prohibition, over-utilization of the soil, and competition from mainland growers most of the vineyards were abandoned. No vineyards remain under cultivation today.

The resort business was never developed on Kelleys to the extent that it was on South Bass. The island economy depended

upon the quarries, vineyards, and fisheries which supported a peak population of 1200 in 1916. Today a permanent population of approximately 150 people depends upon the tourist trade during the summer season as the mainstay of its economy.

Mouse Island

The first recorded visit to Mouse Island was during the War of 1812 when a Captain Bonner and his men spent the night there, describing it as the best accommodations the wilderness could offer. In 1860, Mr. and Mrs. Clark Neal bought the island from Waldo Converse and E.B. Sadler. They operated a small commercial fishery on the island for several years.

When Rutherford B. Hayes returned to his estate in Fremont, Ohio after serving as president of the United States, he bought the island as a retreat for his family and friends. The island remained in the hands of the Hayes estate until Marianna H. Mercer of Rocky River, Ohio bought it in 1966. The only evidence of habitation remaining is an old stone hearth and chimney standing alone amid the dense forest covering the island.

Rattlesnake Island

There is some controversy as to whether the name Rattlesnake Island was derived from the number of rattlesnakes once inhabiting the island or because its shape, with the two small islands at the northwest end resembling rattles, is similar to that of a rattlesnake. The island was once the private summer home of Hubert Bennett, a prominent Toledoan, who stocked the island with wild turkey and golden and ring-necked pheasants (Ross, 1949). Later the island was operated as a fishing and hunting lodge for private parties. Closed in 1970, the resort reopened in 1976 and the restaurant and one lodge are open year-round on a reservations basis only.

The island is also noted among stamp collectors for its unique stamps. In 1966 the island initiated its own local post and puts out a new issue stamp annually, with a mailing list of 2200 customers (Larry Wilson, personal communication).

Gibraltar Island

Gibraltar, so named because of its resemblance to the rock at the mouth of the Mediterranean Sea, was part of the original tract owned by Pierpont Edwards. It went to Rivera in 1854, who in turn sold it to Jay Cooke, Civil War financier. Cooke built a large, impressive, Victorian summer home on the island which he called the castle. Many famous men of that time including Presidents Hayes, Cleveland, and Benjamin Harrison, senators, generals, and financial magnates were lavishly entertained at the castle. Being of strict religious bearing, Cooke invited many clergymen too poor to afford their own vacations for weeks of fishing, sailing and relaxing throughout the summer (Ross, 1949).

While Rivera still owned Gibraltar he offered to donate half of the island for erection of a monument to Perry's victory in the War of 1812. A base was laid in 1858 but the monument was never built. Being an ardent admirer of Commodore Perry, Cooke had a monument built on the existing base when he bought the island. The monument is at the northeast end of the island near Lookout Point where Perry reportedly stationed lookouts to observe the British fleet in the distance.

Between 1873 and 1879 Jay Cooke's company experienced financial difficulties and Gibraltar went into receivership. By 1879 Cooke had rebuilt his fortune, repurchased Gibraltar from the trustee in bankruptcy and reopened his beloved castle (Frohman, 1971a).

In 1925 Cooke's heirs sold the island to Julius Stone who donated it to Ohio State University in memory of his father. Ohio State erected the Franz Theodore Stone Laboratory building and several other buildings and utilized the castle as dormitory space for summer students.

Green Island

Green Island is known on earlier maps as Moss Island and Strontium Island. Large deposits of strontium were found there, but the bulk of the high quality mineral was removed before 1900 (Stuckey and Duncan, 1977). As on all the other islands, Green was lumbered in the 1800's (Behnke et al, 1974).

In 1853 Green Island was purchased by the United States government from the heirs of Pierpont Edwards for the purpose of erecting

a lighthouse. Keepers and their families occupied the island from 1860 to 1915, but after a tragic fire during the winter of 1863 the island was only inhabited during the navigation season (Stuckey and Duncan, 1977). In 1915 the government transferred the light to the Put-in-Bay lighthouse and installed a light with an electrically controlled beacon (Ross, 1949). With the exception of several summer residents prior to World War II, the island has been uninhabited since 1919 (Stuckey and Duncan, 1977).

Ballast Island

Ballast Island was so named because Commodore Perry is said to have removed boulders from its shore for use as ballast in the ships of his fleet. While owned by Rivera, the island was quarried for gravel. In 1869 he sold the island to a private interest (Stuckey and Duncan, 1977).

A large ice house, for storing blocks cut from the frozen lake, was built in 1874 together with a dock for the landing of small steamers. Plans were made to develop a resort community with 25 cottages, a dining hall, kitchen and recreational facilities, but only ten of the cottages were ever built (Frohman, 1974).

A home was built at the edge of the dock for use as a residence for a year-round caretaker. James Fullerton, known more often as Uncle Jimmie, was caretaker for a number of years and lived a hermit-like existence coming to the mainland only once or twice a year for supplies. Year after year Uncle Jimmie would watch the great steamers pass on their way to South Bass Island and finally, in the spring of 1882, he decided to book passage on one for an excursion to Sandusky. On the return trip, aboard the American Eagle, a boiler exploded killing six passengers, the 79 year old Uncle Jimmie among them. He was buried on South Bass Island (Dodge, 1975).

Today the island is privately owned and inhabited only during the summer season. The old caretaker's house lies dangerously close to the rising waters of the lake and may soon be undermined by the force of the waves.

Starve Island

Starve Island is little more than a gravel covered slab of Put-in-Bay dolomite rising just high enough above the lake level to support a few woody species, lichens, and algae. A legend that a human skeleton was found on its shore many years ago, apparently having starved to death, accounts for the name.

Formerly a favored nesting area for terns, the island has been taken over by thousands of herring gulls for the rearing of their young. The island has never been inhabited by man.

Sugar Island

This island was among the original group owned by Pierpont Edwards. Rivera bought it in 1854 and sold it soon thereafter in 1859. It derived its name from the abundance of sugar maple trees on the island. Today the entire island is owned by Gebhard Kenny of Columbus, Ohio and is maintained as a summer residence.

Catawba Island

Now a peninsula, Catawba Island was once separated from the mainland by the Portage River which then emptied into the lake northeast of the island. Rising lake levels decreased the gradient of the old river forcing it to find another outlet farther west (Finkbeiner, Pettis and Strout, 1971). Since the relocation of the river mouth in the late 1800's much of the marshland occupying the old river bed has been drained or filled joining the island with the mainland. A causeway across the eastern end of West Harbor connects Catawba with Marblehead Peninsula. The island is called Catawba after the grape developed in the Catawba, North Carolina region and found to thrive on the islands.

The Ottawa Indians roamed the area for many years and evidence of villages and burial grounds have been unearthed. The Indians left behind many legends, many of them centered on sites along the shore of Catawba Cliffs. One such legend explains the face of an Indian chief carved into a cliff facing the lake shore. Nabagon, a mighty chieftain of the Ottawa Indians and much beloved by his people, was attacked by a fierce panther and lay dying for many days. The Great Spirit was in need of Nabagon's valorous soul to protect him from

enemy gods, and the Indians believed the panther was the Great Spirit himself coming to personally claim the soul of their chief. To appease the grief of the tribe the Great Spirit promised to carve the head of Nabagon in rock to guard the destiny of the island throughout eternity. The next morning an Indian profile appeared carved on the cliff face with a cedar tree at the crest forming the resplendent headress of a great warrior (Prescott, 1922). Although worn by years of weather and loss of the cedar headdress, the face of Nabagon is still visible gazing out across Lake Erie. The tribe left the area in 1831 leaving behind a squaw, Mo John, and her children. Betsey Mo John, one of the squaw's children, married a man who built a hand-hewn log cabin which still stands on the island today.

With the departure of the Ottawas many settlers began moving into the area in the mid-1800's, most of them coming from southern Ohio and Hanover, Germany (Hardesty, 1874). The island soils were found to be ideal for raising fruit, and Catawba became a major producer of peaches, grapes, and apples. The island became famous for the quality of its peaches. Three wine companies prospered on the island - Catawba Wine Company, Gideon S. Owen Wine Cellar, and the Mon Ami. After more than 100 years, the Mon Ami is the only winery still in existence.

During the peak years of the fruit industry a small village known as Ottawa City was formed at the north end of Catawba. A large dock at the site of the present Miller Ferry Dock was operated by the Catawba Island Fruit Company and lake steamers transported tons of peaches and grapes every summer across the lake to Detroit. Just west of the fruit dock was another large dock and warehouse owned by the Booth Fish Company. Ottawa City had its own post office, general store, school, chapel and a number of hotels and boarding houses to serve summer visitors.

Planning to draw more settlers into Ottawa City, J.R. James built a lime kiln and a cooper factory along the northwest shore in 1850 for the express purpose of manufacturing cement. Limestone was quarried along the lake shore just north of the kiln for five years, but the industry did not prosper. The old quarry and lime kiln are still visible today just inside the north entrance to Catawba Cliffs. With improved land transportation and new markets for the island produce, the steamers no longer found business at the fruit dock and Ottawa City was abandoned. Another small village, Peachton, also existed at one time near the center of the island (Carroll et al, 1971).

In the early 1900's the area along the west shore, Catawba Cliffs, was developed as a private housing complex popular with the wealthy of that period for summer homes. All of the original homes still exist and present unique architecture blending beautifully with the natural setting. The J.H. Bellows Company, the firm instigating the development, was instrumental in a proposal to declare the area along the west shore from the Cliffs to Sugar Rock as a perpetual state bird sanctuary, but the proposal was never accepted.

The present state park is located on the site of the former G.W. Snyder and Son Fish Company. A monument commemorating the site of a corner stake marking the boundaries of the Western Reserve is found in the park. Today the island is mostly residential and surrounded by marinas heavily used by boaters during the summer.

West Sister Island

There are few historical records available for West Sister Island. Of all the Lake Erie islands, West Sister has perhaps had the least use as a site for private dwelling.

Indians and early explorers and travelers are presumed to have used the island during storms and as an occasional resting spot. However, the first mention of the island in history is also its most famous. This took place on September 13, 1813 following the Battle of Lake Erie, when Commodore Oliver Hazard Perry defeated the British fleet in a decisive battle of the War of 1812. In a letter datelined "Off Western Sister Island", Perry sent his famous message of victory: "We have met the enemy and they are ours." Both the British and American common seamen killed in the battle were buried just off West Sister by being sewed up in their hammocks with a cannonball at their feet (Dodge, 1975).

West Sister remained undeveloped until 1848 when a lighthouse was constructed on the southwest corner of the island. A photograph of this light and its dock is included in the appendix.

The light keeper's journal from West Sister for the years 1880-1895 is in the Local History Department of the Lucas County Public Library. This journal offers a rare glimpse into the day-to-day life of the lighthouse keeper and his family. Entries were made each

day concerning weather and wind conditions. There are also notations of shipwrecks in the area and of the assistance given by the keeper.

The lighthouse was made automatic in 1937 making it unnecessary to have a keeper on the island. The Coast Guard still maintains a navigation light atop the old lighthouse tower.

The island was made a National Wildlife Refuge by an executive order of President Roosevelt on August 9, 1938 (Toledo Blade, 8/12/38). The island is a nesting ground for large numbers of black-crowned night herons, great blue herons and common egrets.

During World War II the island was used for bombing practice by naval pilots from the Grosse Ile (Michigan) Naval Air Station. In 1967 West Sister was removed from the bombing list (Toledo Blade, 5/12/67).

Johnson Island

Indians of the Sandusky Bay region once used Johnson Island as a torturing ground for their captured prisoners (Ross, 1949). The first historical record of the island occurred during the War of 1812 when a group of settlers were attacked by Indians (Peeke, 1916).

The first owner of Johnson Island was Epiphras W. Bull of Danbury, Connecticut and until 1852 the island was known as Bull's Island. Mr. Bull received the island as a part of the Firelands settlement. Three men built log cabins on Bull Island in 1811 and a village was plotted out. However, the plan to erect a town on the island was abandoned. In 1852 Bull sold the island to L.B. Johnson and the island's name was changed to Johnson Island (Peeke, 1916).

During the Civil War Johnson Island was leased by the government for use as a confederate prisoner-of-war camp. In 1861, Colonel William Hoffman visited all of the Lake Erie islands to select a suitable location for such a prison. He thought that the wine industry on the Bass Islands and Kelleys Island would be too great a temptation to the prison guards. He chose Johnson Island because it was uninhabited and near to Sandusky which would make supplies easier to obtain (Frohman, 1965b).

The prison was completed on February 1, 1862 and prisoners arrived a month later. The prisoners held on Johnson Island were special in that all were officers in the Confederate Army. Thus, the island became infamous in the South as the prison where many of the leading men of the day were incarcerated.

The island never held more than 2500 men at a time but during the period of the war some 10,000 men passed through the prison's gates. The 206 men who died on the island are buried in a small cemetary, which is still maintained by the government. For a detailed account of the prison and the cemetary see Frohman (1965b).

Following the Civil War the prison was abandoned and the buildings and prison items were sold at a public auction. On June 8, 1866 the island was completely evacuated by the government and an orchard was planted on a 150 acre tract. The rest of the island was in oak, hickory and black walnut (Frohman, (1965b).

A resort was opened on the east end of the island in 1894, but it was soon abandoned after a fatal shooting incident for which the resort company was sued. A second resort was begun in 1904, however, it was soon acquired by a competing resort and its buildings were moved to Cedar Point (Frohman, 1965b).

For a time the island was quarried on a small scale and planted in orchards by its new owner Phillipine Dick of Sandusky. Only one family lived on Johnson Island until the 1940's (Toledo Blade, 5/31/38).

In 1956 the Dick estate sold Johnson Island to a group of Cleveland developers for $100,000 dollars. The purchase group was headed by Cleveland Heights realtor Shirley Auslander with three builders as partners: Clifford Reichwein, Walter Zaremba and Herbert Luxemburg. The developers divided the island into 1/4-acre plots all with water frontage. They agreed to preserve the cemetary and to build nothing near it (Toledo Blade, 1/6/56).

In 1974 the Johnson Island developers completed a private causeway to the island from Marblehead Peninsula (Toledo Blade, 7/8/73). Today, little remains of the old prison except the earthworks for the centrally located Fort Hill (see picture in appendix). The cemetary is maintained by a government caretaker, and is the only area accessible to the public. The remainder of the island is ringed by privately-owned cottages.

Turtle Island

Because no composite history of Turtle Island has ever been written, this section describes in greater detail events relevant to Turtle Island from Indian occupation through the Revolutionary War through the "Toledo War" to the present. Most of the information has been compiled from Toledo Blade newspaper articles, lighthouse records, the yearbook of the Associated Yacht Clubs of Toledo, and interviews with the present owner, James Arvanitis.

Just north of Maumee Bay in western Lake Erie lies a small mound of sand called Turtle Island. This small island, today containing only one and a half acres, has had a rich Indian and military history. The Iroquois, Erie, Ottawa and Miami tribes all roamed or settled in the Maumee Bay area (Eckert, 1967 and Fassett, 1961) and probably periodically visited or lived on Turtle Island. Early settlers to the area told of annual visits by Indians to gather the eggs of seagulls (Thal, 1935). Ruins of a lighthouse can be seen on the island today and the "Toledo War" even left its mark on the small isle. To understand how Turtle Island became a part of the United States and Ohio it is necessary to go back to the turbulent period of the Northwest Territory following the Revolutionary War.

Turtle Island was named for Little Turtle, great chief of the Miami tribe in the late 1700's. Little Turtle is best remembered as the conciliator between the Indians and General Anthony Wayne at the Treaty of Greenville in 1795. However, prior to the signing of the Greenville Treaty, Little Turtle was the fierce leader of the Wabash Indian Confederacy consisting of the Piankeshaws, Weas and Miamis. In 1786 Little Turtle had 5000 warriors under his command (Eckert, 1967).

The Miamis had long been an ally of the British forces in their struggle with the French for control of the Northwest Territory. This friendship with the British continued through the Revolutionary War when Little Turtle and his Miamis fought against the Americans on the western frontier. Following the Revolutionary War, even though Ohio was granted to the Americans by the 1783 Treaty of Paris, the British continued to support Little Turtle's Confederacy. Little Turtle was supplied with guns and ammunition by the British and encouraged to harass the American settlers of the Ohio Territory. President George Washington was confronted early in his leadership of the new country with bringing an end to the frontier harassment and British influence among the Wabash Indians.

In 1790 Washington ordered General Josiah Harmer to march from Fort Washington (now Cincinnati) and destroy Little Turtle's villages at the junction of the St. Joseph and St. Mary's Rivers (present site of Fort Wayne, Indiana). Harmer's expedition was soundly defeated by Little Turtle's warriors. The next year, 1791, saw General Arthur St. Clair attempt the same march against the Wabash Confederacy. This expedition ended in "the worst defeat in American military history". Of St. Clair's 920 men, 622 were killed and 264 wounded. Added to this was the massacre of 200 women and children "camp followers" (Eckert, 1967).

It wasn't until General Anthony Wayne's campaign of 1793-1794 that Little Turtle's forces were defeated at the Battle of Fallen Timbers (near present day Maumee, Ohio). This battle led to the signing of the Greenville Treaty in August, 1795.

Also, in 1794 the British built two forts in the Maumee Valley on territory that they had ceded to the Americans in 1783. Fort Miami was built at the head of navigation on the Maumee River (present day Perrysburg, Ohio). The other fort was located on Turtle Island in Maumee Bay, twenty miles northeast of Fort Miami. With these forts the British hoped to keep a foothold in the Ohio Territory and use them as a chain to the fort at Detroit. A letter written by Lieutenant Governor Simcoe of Canada to Secretary of War Lord Dorchester on April 29, 1794 gives us an idea of what Turtle Island fort looked like:

> " I have directed a Log House defensible against musquetry to be built at Turtle Island, and another at River aux Raisens, and merlons of Logs in the Hog pen manner to be provided at those posts which being filled as occasion shall require will give the means of speedily erecting adequate Batteries, and in the mean time these houses will become intermediate deposits, absolutely necessary to the security of the navigation" (Thal, 1935).
> (A merlon is the solid part of a battlement between two openings.)

The Battle of Fallen Timbers took place near the British Fort Miami with General Wayne forcing the Indians up to the gates of the fort. While the Americans under Wayne and the British garrison in the fort did not actually fire upon one another, nevertheless relations between the two countries deteriorated after the battle. Accordingly, in the fall of 1794, the British constructed six gunboats "for patrolling the river (Maumee) and communicating with Forts Turtle Island and Miami" (Thal, 1935). In a letter dated one week after the Fallen

Timbers action Simcoe wrote to a Henry Dundas:

> "The report in Wayne's Army is that he has positive orders to reduce our posts at the Miamis and in the spring to attack Detroit.
>
> "I have detached Captain Bunbury of the 5th Regiment to occupy Turtle Island at the entrance to the Miamis Bay, hoping by a combination of our Gunboats and Vessels at that place to prevent an access to the Miamis River or egress from it" (Thal, 1935).

Tensions between England and the United States in the Northwest Territory ended as the result of a treaty negotiated by Chief Justice John Jay. The Jay Treaty required the British to turn over Fort Miami and Fort Detroit to the Americans in July of 1796. Turtle Island is not mentioned in the Jay Treaty but it can be assumed that it also was included (Knapp, 1872). We can also speculate that the island was abandoned by the summer of 1795 from a disbursement record made by a Lt. Col. R. England on June 13, 1795:

> "...charge of five pounds, seven shillings and six pense, occasioned by removing on sleighs, provisions from Turtle Island to Fort Miamis" (Gibson, 1958).

Even without the Jay Treaty the United States acquired possession of Turtle Island as the result of the Treaty of Greenville, August 3, 1795. This treaty set a boundary line between the lands of the Indians and those of the United States. Roughly, the Greenville Line went from present day Cleveland to near Cincinnati. The Indians' territory fell north of this line and the Americans to the south. In addition to this General Wayne claimed sixteen tracts of land within the Indian territory for government reservations. Article III of the treaty states that one of these tracts shall be "six miles square at the mouth of the Maumee River, where it empties into the lake" (Knapp, 1872). This tract includes Turtle Island and the present site of Toledo.

As he signed the Treaty of Greenville Chief Little Turtle said, "I am the last to sign it and I will be the last to break it" (Tebbel, 1972). Little Turtle kept his word and never again took up arms against the whites. He received a government annuity in his old age and traveled in the East meeting with President Washington. He died at the site of his old village on July 14, 1812 and was given a military burial at Fort Wayne.

The United States government held the island until 1827 when it was sold at public auction in Monroe, Michigan. The buyer was an Edward Bissel of Lockport, New York who settled in Vistula, Ohio (now a part of Toledo). At the time of this sale the island was computed to contain 6.68 acres (Thal, 1935).

Toledo, which at this time consisted of three villages: Port Lawrence, Vistual and Manhatten, showed signs of becoming an important lake port. However, boats entering the Maumee River from Lake Erie had to follow the gentle S-curve of the natural channel that passed to the south of Turtle Island. Realizing the necessity of a lighthouse on Turtle Island to guide mariners through this passage, the government repurchased Turtle Island from Edward Bissel for $300.

On March 31, 1831 Congress appropriated $5000 for a lighthouse (Lt. House Papers, U.S. Dept. of Commerce, 1831-1904, hereafter referred to as "LH Papers") which went into operation in the summer of 1831. Soon after going into service as a light station, Turtle Island began to erode in the wind and waves of Lake Erie. An editorial in the Toledo Gazette on July 2, 1836 described the erosion of the isle:

> "Turtle Island, upon which the lighthouse is erected at the entrance to Maumee Bay, was since our recollection, sufficiently large for a farm of moderate size, and a considerable portion of it covered with wood. Before the erection of the lighthouse (1831), it was reduced to about two acres. Notwithstanding, the government has been vigilant in fortifying it for the past two or three seasons, it is now reduced to somewhat less than an acre, and is gradually wasting, in so much that the structure is in danger, without the immediate care of the government. The immense increase of commercial business in this river (Maumee) demands some prompt action on the part of the citizens of Toledo" (Thal, 1935).

Evidently, this editorial spurred some action for the government spent $16,000 by July, 1838 in the construction of erosion control measures. A plan for the island's protection was drawn up by Isaac S. Smith, who had built the pier and lighthouse at Buffalo. Smith proposed to "draw a continuous row of poles around the island, in close contact, and to fill in behind with stone and brush for the space of twenty feet inward, the island to be reduced in size, and the sand from the area outside of the piles to be thrown over to the area enclosed, and the whole to be covered with good soil" (LH Papers, 1837).

The money spent for erosion control was considered well spent by the Lighthouse Board, for in the annual report the following is found:

> "This light is situated at the entrance of Maumee Bay and is highly useful. It is advantageously situated for directing vessels into this important bay, and no pains or expense should be spared in securing the small island on which it stands from being destroyed by the action of the lake" (LH Papers, 1838).

The report further states that the water level attained by Lake Erie in 1838 was an all-time record.

Table 46 lists the changes in the size of Turtle Island through the years. The Island has never been bigger that 2.5 acres since the construction of the lighthouse.

By 1839 it was believed that the land loss was under control. Isaac Smith had nearly completed the pile driving and stone filling. The lighthouse report for the year was able to state:

> "Turtle Island lighthouse is lighted with eight lamps fixed; the number belonging to the establishment is eleven, with as many bright reflectors. The lamps are in bad condition, from long use. The tender seems to have performed his duty faithfully. This is certainly one of the most important lights on the lake, not only on its proximity to the Maumee River, without which it would be difficult to approach the ports of Toledo and Manhattan, (both thriving villages, which, possessing the advantage of unexceptionable harbors, and with the internal improvements of railroads, etc., some of which are already in operation, must soon acquire a rank among the most favored ports on the shores of Lake Erie) but as a general landmark to the mariner on his passage through the lake. The measures already taken by the government for preserving this island will undoubtedly be amply adequate to the object. The work is progressing rapidly, and will soon be completed. The island does not, at this time, embrace more than three-fourths of an acre of ground. The new channel into the Maumee Bay, which is on the south side of this island, has of late been surveyed, and buoys have been planted, designating the channel, by Captain Dobbins, of the U.S. revenue cutter. The best route through the bay has also been buoyed out" (LH Papers, 1839).

TABLE 46

THE CHANGING SIZE OF TURTLE ISLAND

Date	Acres	Data Source
1827	6.68	Thal, 1935
1836	"somewhat less than 1.0"	Thal, 1935
1837	1.5	Lt. House Papers, 1837
1839	"not more than 0.75"	Lt. House Papers, 1839
1885	1.5	Photostat of Deed, Toledo Public Library
1904	"about 2.5"	Toledo News Bee 12/6/1904
1935	"approximately 1.0"	Thal, 1935
1957	"about 0.5"	Toledo Blade 9/21/57
1958	"less than 2.0"	Toledo Blade 6/1/58
1964	"less than 1.0"	Toledo Blade 9/6/64
1970	"less than 2.0"	Toledo Blade 8/10/70
1977	1.5	Interview with present owner 3/77

After the year 1839 and until the Civil War period the island presented no further problems to the government and continued the routine business of providing navigational aid. At that time it was reported that the original wood lighthouse was dilapidated and would have to be replaced. In 1866, when congress turned to peaceful pursuits, $12,000 was appropriated for "repairs and rennovations at Turtle Island light-station" (LH Papers, 1866).

The new light tower and keeper's dwelling were constructed of "Milwaukee brick" and were considered to be one of the finest lighthouse structures on the Great Lakes. Light from the new tower was first seen on the night of September 12, 1866. It is the ruins of this brick lighthouse that are still visible today on the island.

Problems with the elements do not enter into the Turtle Island records again until the 1870's and 1880's. The following entries are made:

> "The piling and shore protection of part of this island were severly damaged by the great gale of May 15, 1876. Another such storm might seriously endanger the light. New piles and riprap will be put down without delay" (LH Papers, 1876)

> "The pile protection of this island has been much damaged by storms and ice and should be renewed. This can be done at an estimated cost of $3000" (LH Papers, 1881)

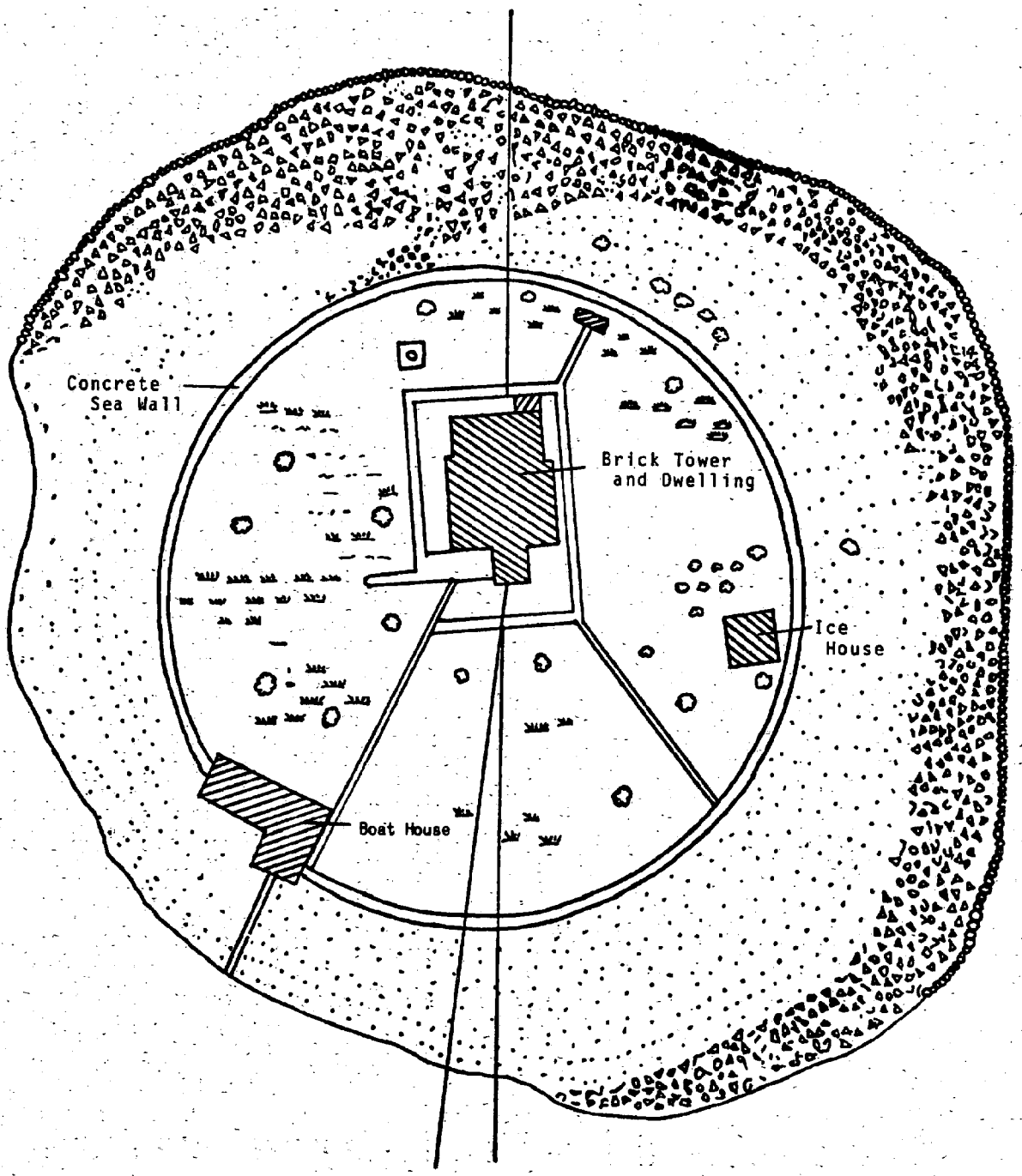
> "The piling and shore protection of part of this island were severely damaged by the spring gales; several such storms might endanger the light. New piles and riprap, at an estimated cost of $15,000 are needed" (LH Papers, 1882)

As a final effort to bring wave and ice damage under control the government constructed a concrete, circular, retaining wall aroung Turtle Island. This wall is 561 feet long with a diameter of 190 feet. At its base the wall is over five feet thick. Figure 34 from a survey of 1885 shows this wall in relation to the light tower and dwelling.

In 1892 a straight channel was dredged into Maumee Bay making the Turtle Island Light obsolete (Herdendorf and Cooper, 1975). Plans were made for dismantling the lighthouse as soon as the new Toledo Harbor Light was completed.

FIGURE 34.

MAP OF TURTLE ISLAND, CIRCA 1885.



The last entries are of interest:

"This fourth-order white light was, on May 15, 1904, permanently discontinued. Its fourth-order lens was dismounted, and packed and with the rest of the illuminating apparatus, was taken to the Maumee Ranges light-station to be shipped to the Buffalo lighthouse depot" (LH Papers, 1904).
[Fourth order light was a term used in the days of kerosene lamps. It was the lowest power used and visible under clear conditions for a distance of six miles.]

"The light was discontinued, and this property was on December 6, 1904, sold at public auction" (LH Papers, 1905).

A newspaper story about the sale of the island began:

"What the washing waves have left of Turtle Island will be offered for sale at auction at the Toledo customs office at noon tomorrow" (Toledo Blade, 12/5/1904).

At this sale Turtle Island was purchased for $1,650 by A.H. Merrill representing George Craig. The sale included all buildings which, besides the 1-1/2 story brick dwelling and tower, included a boathouse, ice house, and woodshed. The deed also included the riparian rights (Toledo NewsBee, 12/6/1904).

The speculation at the time of the sale was that the island would be turned into a summer resort. However, nothing was done with Turtle Island by its new owners between 1905 and 1933. The buildings soon fell into ruins with vandals aiding in the process by "stealing everything that could be salvaged from the structure except the grim, bare walls" (Toledo Blade, 2/15/29). During this time the island was used by an occasional fisherman and as a rendezvous for boating parties.

In May, 1933 the Associated Yacht Clubs of Toledo leased the island for "the purpose of establishing a Yacht Club and a harbor of refuge" (Thal, 1935). The lighthouse was restored and the island became a focal point for area yachting activities until 1937 when the lease was not renewed. Before the island was returned to its owner, A.H. Merrill, the Associated Yacht Club proposed that the state purchase the island for conversion into a state park and harbor of refuge. However, the State Conservation Council rejected the idea on the grounds that "the tract would not be of sufficient public benefit to justify the purchase" (Toledo Blade, 6/24/36).

The State of Ohio did, however, make use of Turtle Island as a monument point marking the boundary between Michigan and Ohio. The two states had experienced a boundary dispute since the time of the "Toledo War" in 1836 when both Ohio and Michigan claimed the Toledo area (for the full story see George, 1971). In an effort to end uncertainty concerning the boundary, the legislatures of Ohio and Michigan in a joint resolution dated June 8, 1933 (Senate Joint Resolution No. 25, 90th Ohio General Assembly) established the boundary as a "line drawn south forty-five degrees west through the center of Turtle Island", and "from the center of the wall the boundary in Lake Erie shall extend north forty-five degrees east until it shall intersect the international boundary between the United States and Canada".

Turtle Island changed hands again in the late 1950's when it was purchased by the Toth Motorship Transportation Company of Toledo. The Toth Company dredged in the vicinity of the island, but did not make any actual use of the island. The company did, however, lease the island for two seasons (1958-1959) to a Toledo concessionaire, Russel Kisseberth, who sold beer and sandwiches to boaters. Kisseberth constructed a boat dock, but made no other improvements (Gibson, 1958).

The present owner, James Arvanitis of Toledo, acquired the island from the Toth Company in August, 1969. Arvanitis was a stockholder in the Toth Company and received Turtle Island when the company was unable to repay a $20,000 loan. Arvanitis currently pays $420 annually in taxes on Turtle Island. Interestingly, he pays $330 to Monroe County, Michigan and only $90 to Lucas County, Ohio; Turtle Island is exactly one-half Michigan and one-half Ohio.

DEMOGRAPHY AND ECONOMIC SETTING OF THE LAKE ERIE ISLAND REGION

Population

People are an important resource in any area. This is no exception in the island area. The local population serves as a labor force and determines the number of housing units required and the service enterprises which can function profitably in the area. Population records and projections for island area townships and incorporated villages are presented in Table 47. The trend of the period 1940-1970 is one of general decline on the islands proper (Put-in-Bay Twp.) and one of increase in the adjacent mainland area (Catawba Island Twp.) Population projections developed by the consulting firms of Finkbeiner, Pettis and Strout, Ltd., of Toledo for Ottawa County and Parkins, Rogers & Associates, Inc., of Detroit for Erie County indicate a gradual increase through 1990. To date, the actual populations have failed to keep pace with the projections. These inconsistencies are the result of failure of the methodology employed to predict trends because of the specialized nature of the Lake Erie Islands. The islands can be expected to support a larger permanent population only with the development of additional year-round employment opportunities. Inspection of recent population characteristics of island townships (Table 48) indicates a disproportionate number of young and elderly in the islands proper. This condition is the result of the necessity for numbers of the wage-earning age group to seek employment in other areas. The general trend is an out-migration of this segment of the population. In the period 1940-1970, the demise of commercial fishing, quarry and winery enterprises has accelerated the out-migration process. The high proportion of elderly, i.e. retired, persons residing on the islands proper compared to the adjacent mainland is evident in the lower person per household statistic in Table 48.

Schools

Kelleys Island, North Bass Island, Middle Bass Island and South Bass Island voters elect local boards of education and support local schools. Public schools serving island residents are characterized in Table 49. In the Bass Islands, only Put-in-Bay School provides high school (grades 9-12) education. Students from the other islands are transported by air to South Bass Island during their high school years. North Bass Island School's enrollment varies with the number of migrant farm workers employed on the island during the school year. Schools in the Bass Islands

TABLE 47

POPULATION PROJECTIONS AND RECORDS BY
TOWNSHIPS AND INCORPORATED COMMUNITIES 1940 - 1995

	1940[2]	1950[2]	1960[2]	1970[2]	1975	1980	1985	1990	1995
Townships									
Catawba Island[1]	462	780	1,769	2,882	3,550	4,000	4,600	4,900	5,100
Danbury Township[1]	2,483	3,222	3,526	3,760	4,050	4,100	4,600	4,800	5,000
Put-in-Bay[1]	609	598	462	507	550	600	650	650	700
Incorporated Communities[3]									
Kelleys Island[4,5]	564	324	171	130	170	200	250	320	---
Put-in-Bay[1]	NA[6]	NA	NA	140	150	160	170	180	200

1 General Implementation Study and Housing Recommendation. Finkbeiner, Pettis and Strout, Ltd.

2 Actual Census Count

3 Figures rounded to nearest ten

4 Comprehensive Development Plan Erie Region, Ohio. 1970. Parkins, Rogers and Associates.

5 Overall Economic Development Progran. 1963. Kelleys Island Redevelopment Area Organization

6 Not Available

TABLE 48

HOUSEHOLDS AND POPULATION CHARACTERISTICS BY TOWNSHIP, 1970-1975

Township	Number of Households[1]	Person per Household[1]	Young Adults (Age 15-19)[2]	Elderly (65+)		Non-White (Number)[1]
				Number[1]	Percent[2]	
Catawba Island	922	3.12	264	257	8.9	11
Put-in-Bay	176	2.88	46	95	18.7	9

1 U.S. Bureau of the Census, 1970

2 Vol. 1: Population and Economic Study, 1971. Finkbeiner, Pettis and Strout, Ltd.

TABLE 49

INVENTORY OF ISLAND PUBLIC SCHOOLS, 1961-1977

School	Township	Grades Inclusive	Size of Site (Acres)	Enrollment			No. Teachers 1977
				1961	1971	1977[2]	
				(K-8)	(K-4)	(K-3)	
Catawba Elementary	Catawba Island	K-3	2.5	337	175	185	8
Clay Center Elementary	Catawba Island	K-6	-	48	School Closed	-	-
Estes Kelley	Village of Kelleys Island	K-12	3	25		19	3
Middle Bass	Put-in-Bay	K-8	0.8	4	10	9	1
North Bass	Put-in-Bay	K-8	0.7	10	13	12	1
Put-in-Bay	Put-in-Bay	K-12	2	64	89	74	8 (2 part-time)

[1] Jan., 1977

are administered as part of the Ottawa County Board of Education while the one on Kelleys Island is administered by the Erie County Board of Education.

Each local board is supported by property taxes voted by local residents. The maintenance of local school systems is, in part, due to the large number of cottages owned by residents of other communities. This influx of tax dollars from other than purely local sources permits millage levels lower than otherwise required for the support of local schools. North Bass Island School is supported in large part by Meiers Wine Cellars, Inc.

Employment

The island region is unique in that seasonal recreation activities contribute significantly to the economy in terms of incomes and employment (Comprehensive Development Plan, Erie County). Services, amusement, recreation and retail trade show dramatic increases from May through September with the peak period extending from mid-June to Labor Day.

Cottage owners, boating enthusiasts and tourists on extended vacations increase the local population during this period. The resultant increase in seasonal employment in the retail trade and service industries is largely due to this large population influx. During the remainder of the year, many local residents are unemployed or self-employed on a part to full-time basis utilizing self-developed skills in a variety of service enterprises. During the summer season, most island families are fully occupied in income-earning activities.

Full-time employment, for the most part, is provided only by public institutions maintaining facilities and/or services on the islands. The relatively large resident population on South Bass Island is the result of two factors: (1) the large number of governmental facilities sited on the island, and (2) both ferry companies serving the Bass Islands are headquartered on the island rather than on the mainland (Table 50). The wineries on Middle Bass and South Bass Island are supported almost entirely by on-site visitors. Only a small portion of the production of these wineries is sold outside the island region.

TABLE 50

PRINCIPAL EMPLOYERS IN THE ISLAND REGION

	summer	spring/ fall	winter
State of Ohio			
Catawba State Park			
East Harbor State Park	(48)[1]	(10)	(10)
Kelleys Island State Park	9	2	2
Ohio State University	50	12	12
South Bass Island State Park	10	4	4(3 CETA)
United States Government			
Isle St. George Post Office	1	1	1
Kelleys Island Post Office	2	1(1 pt.tm.)	(1 pt.tm.)
Middle Bass Post Office	1	1	1
Perry's Monument	18	6(1 CETA)	6(1 CETA)
Put-in-Bay Post Office	2	1(1 pt.tm.)	1(1 pt.tm.)
Townships and Villages			
Estes Kelley School	-	4	4
Middle Bass School	-	1	1
North Bass School	-	1	1
Put-in-Bay School	-	10(1 CETA)	10(1 CETA)
Put-in-Bay Police	2	2	2
Put-in-Bay Streets and Highways	5	5	5
Kelleys Island Streets and Highways	3	3	3
Airlines			
Griffing Flying Services			
Sky Tours, Inc.	5 (9)	1 (9)	1 (9)
Boat Lines			
Miller Boat Lines	16 (2)	12 (1)	-
Neuman Boat Lines	1 (25)	1 (10)	(6)
Parker Boat Lines	6 (3)	3 (2)	-
Wineries			
Bretz Winery (Middle Bass)	3	6	1
Meier's Wine Co. (North Bass)	6	12	6
Heineman Winery (South Bass)	8	4	4

[1] Mainland-based employees denoted by parentheses.

Housing

A major factor affecting the population in the island region is the total number and the condition of housing. Residential housing on the islands proper (Put-in-Bay Twp.) is almost entirely 1 or 2 family units. Land use for housing purposes is summarized in Table 51. Very few multiple family, i.e. apartment, dwellings occur in the area (Table 52). Local zoning severely limits the number and dispostion of mobile homes. The majority of residential units are summer cottages unsuitable for year-round habitation. The number of all year housing units is limited. Individuals and families moving to the islands proper discover very few year-round units available. The condition of existing (1971) all-year housing units is summarized in Table 53.

The islands are underlain by limestone bedrock at depths of a few inches to several feet. As a result, residential development on the islands is limited by shallow rock. Sewage treatment in the islands is almost entirely of the single unit septic tank variety. Local public health regulations severely limit residential development with individual sewage systems in shallow bedrock areas. In addition, residential development is limited by soil wetness problems in the vicinity of wetlands (Comprehensive Development Plan, Erie County, 1970).

Postal Service

The U.S. Postal Service maintains post offices on Kelleys, North Bass, Middle Bass, and South Bass Islands. Mail is delivered by air to these post offices on a contractual basis by Sky Tours, Inc. All postal service is classified as Non-City-Delivery, i.e. residents must pick-up mail at the post office. On Middle Bass and North Bass Islands the post office is located in the postmaster's home. The North Bass Island post office maintains its historic continuity with Isle St. George as its official name.

Rattlesnake Island is not served by the U.S. Postal Service. The owners of this island annually issue a series of stamps for the private mail service to the island. Over 2000 philatelists subscribed to the 1977 issue. In fact, the island maintains a post office box at the Port Clinton Post Office.

TABLE 51

EXISTING LAND USE SURVEY, 1970 (IN ACRES)

	Catawba Is. Township	Put-in-Bay Township
Total Area	3,610	2,842
Residential		
1-2 Family	1,227	544
Multiple	11	2
Employment Areas and Centers		
Agricultural (General)	1,484	880
Agricultural (Specific)	62	506
Manufacturing	15	16
Extractive	0	1
Commercial	163	191
Governmental & Inst.	12	19
Movement Systems		
Township highways	32	65
County highways	23	27
State highways	46	11
Non-highways R/W	51	55
Recreation and Open Space		
Local Community Parks	0	11
Non-local recreation & open space	348	332
Wooded areas	59	115
Swamp & Marsh	26	63

1

Vol. 2. Regional Development Plan. Finkbeiner, Pettis and Strout, Ltd.

TABLE 52

ESTIMATE OF ALL YEAR HOUSING UNITS,
HOUSING BY TYPE AND DEFICIENT UNITS, 1970

Township	All Year Housing Units[1]		1 & 2 Family[2]	Mobile Homes[2]	Multiple[2]	Number of Deficient All Year Units[3]	Per Cent of Deficient Units
	Total	Per Cent of County Total					
Catawba Island	1562	10.2	1,497	823	14	60	3.84
Put-in-Bay	589	3.9	681	59	3	37	6.28

1 Master Enumeration District List, 1970 U.S. Census of Population and Housing

2 Existing Land Use Survey. Finkbeiner, Pettis and Strout, Ltd. March, 1971.

3 Vol. 2: Regional Development Plan. Finkbeiner, Pettis and Strout, Ltd.

TABLE 53

CONDITION OF HOUSING IN ISLAND TOWNSHIPS,
NUMBER OF DEFICIENCIES PER TOWNSHIP, 1970 [1,2]

Deficiencies	Catawba Township	Put-in-Bay Township
Major Items		
1. Walls out of plumb	2	1
2. Sagging roof	-	1
3. Foundation out of level or breaking up	1	2
Minor Items		
1. Loose or missing wall materials	16	11
2. Windows broken or boarded up	8	4
3. Shingles missing from roof	16	17
4. Structure in need of paint	113	52
5. Gutter and/or downspouts, rusted through or falling off	6	2
6. Porch or stairs rotting, out of level or pulling away	6	4
7. Chimney leaning and/or part missing	3	4
8. Exterior stairway of substantial height without railing	-	-
9. Doors in need of repair	2	2
Summary		
1. Minor repairs subtotal + 3 = C	57	33
2. A + C totals added = Composite score	60	37
3. Number of permanent residence structures	1511	684
4. Per cent of deficiencies per permanent residence structure	3%	5%

1 Vol. 2. Regional Development Plan. Finkbeiner, Pettis and Strout, Ltd.

2 Field Survey, 1971

RECREATION IN THE LAKE ERIE ISLAND REGION

The Lake Erie islands possess a number of the attributes required of an important recreation/vacation area: (1) pleasant scenery, (2) availability of outdoor activities, (3) minimal pollution, and (4) low crime rate. Visitors to the islands leave behind a number of features common to more urban areas: (1) diversified shopping facilities, (2) availability of a diversity of social, cultural, and educational activities. The latter are largely lacking in the islands.

The major recreation use period is the summer season, extending from Memorial Day in May to Labor Day in September, the peak use months being July and August. The number of visitors to the islands during the remainder of the year is comparatively very small. This study has identified 4 categories of summer recreational users: (1) day visitors (2) individuals who are spending one or more nights camping, (3) individuals who are spending one or more nights at a private resort/cottage, and (4) summer-long residents who usually reside in a retirement-type residence. These categories are ranked in order of frequency. The latter two categories of visitors are most important in terms of their contribution to the local economy. The islands offer the opportunity for fishing, camping, hiking, picnicking, power boating, sailing, sightseeing, sunbathing, and swimming during the summer season. Points of origin for island visitors is summarized in Table 54.

The recreational opportunities found in the island region are by no means limited to the summer season. The principal activities are listed by season:

(1) winter: iceboating, ice fishing, ice skating, sledding, and snowmobiling

(2) spring: fishing, sightseeing

(3) fall: fishing, hunting

Individuals attracted by the winter, spring and fall opportunities are largely day visitors, the exception being cottage owners who frequent the islands in the spring and fall.

Summer

Camping. Kelleys Island and South Bass Island State Parks, along with the adjacent mainland areas of Catawba Island and Marblehead peninsula, attract family campers. In addition, several groups conduct

TABLE 54

COMMUNITIES IDENTIFIED WITH CITIZENS UTILIZING THE LAKE ERIE ISLANDS AS RECREATION POINTS

100 mile radius of Put-in-Bay		100 to 150 mile radius		150 to 200 mile radius	
Ohio	Population	Ohio	Population	Ohio	Population
Cleveland	2,064,194	Columbus	916,228	Cincinnati	1,384,911
Toledo	692,571	Dayton	850,266	Hamilton/ Middletown	226,207
Akron	679,239	Steubenville/ Weirton, W. Va	165,627	Kentucky	
Youngstown/ Warren	536,003	Springfield	157,115	Ashland	29,245
Canton	372,210	Indiana		Catlettsburg	3,420
Lorain/Elyria	256,843	Fort Wayne	280,455	Covington	52,535
Lima	171,472	Pennsylvania		Indiana	
Mansfield	129,997	Erie	263,654	South Bend	280,031
Sandusky	32,674	West Virginia		Anderson	138,451
Port Clinton	7,202	Wheeling	182,712	Muncie	129,219
Michigan				Pennslyvania	
Detroit	4,199,931			Pittsburgh	2,401,245

[1] U.S. Census, 1970

organized youth camps in the island area. The principal destination points for family campers are the state parks of the region. Organized youth camps are located, with one exception, on Kelleys Island.

The largest and most popular state park in the region is East Harbor State Park. Park visitation figures are presented in Tables 55-58. These visitation figures are estimates designed to include 'scenic drivers' and must be considered maxima. Facilities at island parks are summarized in Table 59. During the Memorial Day, Fourth of July and Labor Day holiday periods, all the parks in the region fill to capacity and are forced to turn campers away. Inspection of park registrations indicates the majority of users are from metropolitan areas in northern, central and southwestern Ohio. Out-of-state registrants are uncommon.

Two private camps, Camp Patmos and the Kelleys Island 4-H Camp, currently operate during the summer months on Kelleys Island. The Cleveland Museum of Natural History and the Great Trails Council, B.S.A., own property on Kelleys Island. The latter two groups would like to establish summer youth camps on their properties but are currently prevented by shortages of development funds. The Ohio State Music Camp attracts talented high school age musicians and music teachers to the summer program conducted annually on South Bass Island.

Fishing. Anglers from throughout Ohio and several neighboring states make periodic fishing trips to the island region during the summer months. Many rent dock space and moor boats at Catawba Island marinas. Others tow small boats and rent cottages or camp at the State Parks. The chief attraction is perch, walleye and bass fishing on the island reef areas. During the Memorial Day, Fourth of July and Labor Day periods, thousands of boats concentrate on the reef areas. The most popular reefs are Mouse Island reef near Catawba Island; Gull Island reef and Kelleys Island Shoal near Kelleys Island; West Reef near North Bass Island; Buckeye Island and Starve Island reef near South Bass Island; and the Niagara/Toussaint reefs west of the Bass Islands. A number of large "party" boats operate from Port Clinton and Sandusky and transport groups of fishermen to the reef areas almost daily during the summer months.

Rental cottages in the island area are used largely by family and community groups on fishing vacations. The largest number of rental cottages are located on Catawba Island. On the islands proper, rental cottage complexes are located on Kelleys Island (11), Middle Bass Island (1), and South Bass Island (6). A disproportionate number of cottage rentals are made by southern Ohio residents.

TABLE 55

CATAWBA ISLAND STATE PARK MONTHLY VISITATIONS (1971 - 1976)

	1971	1972	1973	1974	1975	1976
January	15135	6183	2439	3017	6270	12112
February	10359	11163	2060	2446	5258	21401
March	8393	6766	2622	2462	6522	17335
April	17978	13643	31102	27192	10382	18987
May	67230	19235	39713	50367	72263	32872
June	68869	23689	50924	34418	72242	61879
July	51670	45516	61867	113730	105745	67228
August	46494	57368	79368	106821	95762	51328
September	48884	60461	87239	62079	55412	22329
October	37269	26326	39012	43064	33522	11738
November	9333	10165	10552	16674	17126	3689
December	Unknown	3125	3572	5932	3000	1532

TABLE 56

EAST HARBOR STATE PARK MONTHLY VISITATIONS (1974 - 1976)

	1974	1975	1976
January	10779	12605	10850
February	25909	26301	26210
March	29752	26502	35000
April	65801	42010	80000
May	94630	135720	121500
June	179988	233410	238232
July	419998	489171	304842
August	351785	348240	355280
September	87396	92676	105459
October	28980	29778	31450
November	19071	19750	19860
December	6181	17342	19860

TABLE 57

KELLEY S ISLAND STATE PARK MONTHLY VISITATION (1971 - 1976)

	1971	1972	1973	1974	1975	1976
January	391	204	324	544	487	757
February	354	1007	365	408	377	518
March	282	307	475	421	431	464
April	1993	592	1010	1298	424	2294
May	2389	4366	16348	4057	11071	12064
June	9496	8147	42039	7581	20098	23310
July	19693	18113	111049	17626	39122	33224
August	22429	16999	93891	23491	34416	26526
September	4848	3944	24505	1663	5873	6151
October	Austerity closing	1100	8322	1895	2448	3072
November	343	536	4514	432	894	2183
December	251	324	619	400	300	606

TABLE 58

SOUTH BASS ISLAND STATE PARK MONTHLY VISITATIONS (1971 - 1976)

	1971	1972	1973	1974	1975	1976
January	435	192	3433	200	4796	9342
February	312	1335	4070	5296	4153	10412
March	255	279	2390	5058	4420	Unknown
April	524	334	10364	3571	13254	6220
May	6846	9344	20730	58615	55317	20871
June	13332	9099	70894	83405	89161	49161
July	13033	15940	97983	108741	129981	90631
August	12370	6814	193172	120337	158686	81383
September	2889	6307	37525	13307	7638	23572
October	Austerity Closing	2785	9414	10282	4279	7767
November		1828	5524	3902	4637	4662
December		2818	4125	250	250	4301

TABLE 59

STATE PARK FACILITIES

Facilities	Kelleys Island	South Bass Island
Campsites	150	125
Rent-a-Camp (fully equipped campsites)	2	0
Rental cottages	0	2 (6, 8 people)
Boat launching ramp	YES	YES
Overnight boat docks	0	15 (30)
Bathing beach	Sand, guarded, 10 a.m.-dusk 5/30-9/6	Cobble - unguarded
Change booth for bathers	YES	NO
Electric Power	NO	NO
Restrooms	Vault-type latrine	Vault-type latrine
Picnic facilities	Fire rings, grills, picnic tables	Fire rings, grills, picnic tables
Showers	NO	NO
Water	Safe drinking water on tap	Safe drinking water on tap
Fees	$2.25/campsite Organized groups - $.25/person	$2.25/campsite
Restrictions	No pets No alcoholic beverages	No pets No alcoholic beverages
Emergency boat	NO	YES

Hiking. The island region is not a backpacking area. The only opportunities for genuine day hiking are found in the quarries on Kelleys Island. The hiking and exploring of these quarries is enhanced by the abundant fossil fauna to be uncovered in the exposed strata. The limestone strata and fossil fauna of each quarry are listed in Appendix A.

Picnicking. Facilities for picnicking are limited. The state parks and village parks on Catawba Island, Kelleys Island, and South Bass Island are developed to allow picnicking activities. Local facilities on these islands are designed to encourage visitors to use local food concessions rather than picnic.

Power boating. A major influence in the growing interest in the Lake Erie islands has been the expansion of recreational boating. Recreational power boating falls into two distinct, although occasionally overlapping classes: fishing and cruising. In both instances, activity is centered in the island region. The islands are located 35 miles from Lorain Harbor Light, 29 miles from Detroit River Light and 28 miles from Toledo Harbor Light. These distances make the islands favored destination points for power cruisers located in these metropolitan areas.

Approximately 5000 power boats are moored at West Harbor/Catawba Island marinas during the summer months (Table 60). The principal use for 70% to 80% of these boats is reef fishing. The remaining 20% to 30% are used for cruising. The boating boom has caused problems in the island area. The noise of high-powered vessels speeding along the islands destroys the desirability of shoreline properties as quiet places. The huge concentration of power and sailing craft located at West Harbor marinas creates hazardous conditions at the only entrance, Gem Beach, to West Harbor. Local marina owners are universally, and adamantly, in favor of opening another channel to the West Harbor area in order to relieve the congestion at the privately maintained Gem Beach channel. This situation, in part, contributes to making the Marblehead Coast Guard Station one of the two busiest stations on the Great Lakes, in terms of distress calls.

Sailing. Although not as common as power boats, a variety of sailing craft are used as recreational vessels in the island region. Put-in-Bay Harbor is used by numerous Lake Erie yacht clubs as a destination point for week-end sailing races. Most importantly, the associated members of the Inter-Lake Yachting Association hold the Association's annual regatta at Put-in-Bay. Participants from associate clubs in Michigan, Pennsylvania, Ohio and Ontario sail marked courses in the vicinity of the Bass Islands throughout the first full week in August. This event, known as the 'Interlake', is sometimes advertised as the world's largest freshwater regatta.

TABLE 60

MARINA AND DOCK FACILITIES OF THE LAKE ERIE ISLAND REGION

Marina	Location	# Docks	Principal Points of User Origin	Service
Burgundy Bay	Middle Bass	16	Privately owned finger docks; members only	No Service Facilities
Catawba Island	Catawba Island	300	Members only - local	Full Service: Gas, boating supplies, storage
Catawba Midway	Catawba Island (West Harbor)	145	Cleveland, Columbus, Mansfield	Gas, boating supplies, restaurant, bath/shower, storage
Cedar Point	Sandusky	750	Cleveland, Columbus, Other, Local (50)	Gas, pump-out, 2 restaurants, swimming pool, laundromat, water-taxi
Chafee's	Catawba Island (West Harbor)	95	Cleveland, Columbus, Dayton	Gas, pump-out, picnic facilities, fishing licenses (200)
Crew's Nest/ Lake Erie Patrol	South Bass		Catawba Island, Port Clinton, Cleveland, Toledo, Sandusky, local	Gas, pump-out, supplies, restaurant, water-taxi
Foxhaven	Catawba Island (West Harbor)	500	Cleveland, Columbus, Cincinnati	Gas, pump-out, picnic table, water, electric
Gem Beach Service	Catawba Island (West Harbor)	480	Cleveland, Columbus, Cincinnati, Indiana	Full service: machine shop, canvas shop, boat storage, hoists
Green's	Catawba Island (West Harbor)	202	Cleveland, Columbus, Dayton, local	Full service, machine shops
Herls	Catawba Island (West Harbor)	25	Columbus, Springfield, Marion	Docks only
Ladds	South Bass	11	Local	Small rental boats and motors
Lonz	Middle Bass	9	Large boat-basin-abandoned, 9 useable docks, remainder of docks in disrepair	No service facilities
Parker's	South Bass	600 ft. dockspace	1 deep draft dock for vessels 100-200 ft. in length	Gas
Peterson's	Catawba Island (West Harbor)	50	N.A.	Dockage for adjacent trailer park resort
Put-in-Bay City Docks	South Bass	1300 ft. dockspace	Catawba Island-West Harbor, Cleveland, Toledo, Detroit, Sandusky	Docks, restrooms in adjacent city park

TABLE 60 CON'T.

MARINA AND DOCK FACILITIES OF THE LAKE ERIE ISLAND REGION

Marina	Location	# Docks	Principal Points of Origin	Service
South Bass Island State Park	South Bass	30	Cleveland, Columbus, Toledo	Docks, latrines, picnic tables
Seaway	Kelleys Island	200	Cleveland, Sandusky local (50)	Gas, boating supplies
Sugar Rock	Catawba Island	150	Columbus, local	Gas, mechanical, dry storage, boating supplies
Treasure Cove	Catawba Island	30	Mansfield, Columbus, Youngstown, Penn.	Gas, mechanical
West Catawba	Catawba Island	110	N.A.	Gas, hoist, storage

Sightseeing. In the island region, Kelleys Island and South Bass Island are the principal islands where sightseeing is an important recreational activity. As a result, only these islands, along with Catawba Island, are developed as public resort areas. Sightseeing opportunities in the remainder of the island region are of minor importance. The remaining islands are largely privately owned and developed as retreats or as agricultural areas.

Scenic points in the island region are summarized in Table 61. The scenic features not open to public inspection are noted. On South Bass Island the principal points of visitor interest are Crystal Cave/ Heineman Winery and Perry's Monument. Some visitors come to South Bass Island to visit one or the other site only. Other visitors attempt to see as many points of interest as the length of their visit permits. Inevitably, Put-In-Bay village attracts many who initially intend the trip to the island as a visit to Perry's Monument or the Winery. On Kelley's Island the glacial groove area and inscription rock are the principal points of scenic interest. Rental bicycles are the most common form of transportation for those visiting scenic features for a day.

In terms of public interest, Perry's Monument is best considered a regional rather than a national site. Inspection of the monument guest register on any given day reveals an overwhelming preponderence of Ohio residents (90%). Residents of neighboring states compose the remainder of the visitors. Visitors from Michigan are almost entirely waterborne. Young people (18-24) predominate on weekends while family groups are most common during weekdays. Monthly attendence figures are presented in Table 62. Attendence figures are computed as the actual count of visitors taking the elevator ride to the observation deck plus 20% of that figure for visitors to the grounds who do not visit the observation deck. The staff conducts a variety of informative presentations during the evening hours throughout the summer months. The monument is open to the public from early May to late October (C. White, Chief Ranger, personal communication).

The Ohio Division of Wildlife Fish Hatchery staff conducts visitors through the facility weekdays from 1:00 to 4:00 p.m. and by reservation at other times. Individual tours vary and center around the particular activities ongoing at the hatchery at the time. The number of visitors (Table 62) would be much higher if the facility were open to the public during the weekend period. Opening the hatchery on the weekend would be a public relations enterprise unrelated to its primary function as a site for fish propagation.

TABLE 61

SCENIC POINTS OF INTEREST

Catawba Island

Catawba Cliffs/Nabagon Head[2]
Catawba Island State Park
marinas/boats
Mon Ami Winery/Restaurant

Johnson Island

Confederate Officer's Cemetary[1]

Kelleys Island

glacial grooves
Inscription Rock
Kelleys Island State Park
Kelleys Island Wine Cellar ruins
quarries
quarry docks
village pavilion

Marblehead Peninsula

Marblehead lighthouse[2]
quarries

Middle Bass Island

Lonz Winery building[2]
vineyards

South Bass Island

Battle of Lake Erie
Coast Guard Lighthouse[2]
Cooke Mansion[2]
Dollar Mansion[2]
Gibraltar Island/Stone Laboratory[2]
Heineman Winery and
Crystal Cave
Island Airlines Ford Tri-motor
airplane
lime kiln
Miller Mansion[2]
Perry's Cave
Perry's Victory Monument and
International Peace Memorial
Put-in-Bay harbor/boats
Put-in-Bay village park
Put-in-Bay village bars/restaurants/
shops
Ohio Division of Wildlife Fish
Hatchery
rocky cliffs
South Bass Island State Park/
Victory Hotel site ruins

[1] public access by boat only
[2] no public access or controlled access

TABLE 62

ANNUAL VISITATIONS TO ISLAND PUBLIC CAMPGROUNDS AND PERRY'S MONUMENT

Year	Catawba Island State Park	East Harbor State Park	Kelleys Island State Park	Perry's Victory and International Peace Memorial	South Bass Island State Park	State Fish Hatchery
1976	322,320	1,848,543	98,169	107,741	308,242	3133
1975	483,504	1,473,511	115,941	101,940	476,572	N.A.
1974	518,202	1,320,270	59,816	107,335	412,964	N.A.
1973	410,356	Figures Unavailable	303,461	90,635	459,624	2534
1972	283,640	N.A.	55,639	90,322	57,075	1420
1971	381,614	N.A.	62,469	94,899	50,345	N.A.
1970	365,335	N.A.	16,668	92,587	39,288	N.A.
1969	440,180		17,477	78,848	35,726	
1968	364,689		18,726	85,958	33,787	
1967	320,584		15,351	87,041	38,803	
1966	357,680		10,324	83,292	29,298	
1965	406,595		8,238	79,090	28,077	
1964	292,565		1,667	78,970	31,500	
1963	294,530		-	74,083	24,571	
1962	253,625		-	69,628	19,937	
1961	245,745		-	61,675	22,768	
1960	281,786		-	66,865	36,734	
1959	313,045		-	63,707	52,368	
1958	322,545		-	51,095	31,721	
1957	314,980		-	57,786	55,309	
1956	138,844		-	45,389	27,869	

Heineman's Winery is a major island attraction. In addition to tours of the winery proper and the "wine sampling" room, tours of Crystal Cave, located beneath the Winery, draws many visitors. Nearby is Perry's Cave, allegedly used by Commodore Perry and his men during the War of 1812. Perry's Cave is currently operated as a tourist attraction.

A number of old mansions and ruins of once prominent structures are scattered throughout the islands. The Victory Hotel ruins are located within the limits of South Bass Island State Park.

Put-In-Bay Village Park offers a picturesque view of the island specialty shops, the harbor and Gibraltar Island. On weekends and during regatta, the harbor and village docks are filled with sailing craft and power boats. The scenery along the west shore of South Bass Island is dominated by high rocky cliffs.

Another drawing force to the islands is the "myth of the wine festival ". Across the State of Ohio there persists the idea that the Bass Islands sponsor a "wine festival" each year. This idea is most prevalent in the minds of the youthful 18-24 year-old age group. This myth is probably the result of the huge Memorial Day tourist influx, stories or accounts of which eventually lead to the conclusion in the minds of the uninitiated that a wine festival is sponsored on the islands.

Visitors to Kelleys Island are drawn by the glacial grooves and Inscription Rock. A visit to the grooves usually entails a tour through the State Park and along the sand beach bordering the north shore. The old quarries and their related kilns and docks are also of interest to sightseers. Located along the south shore of the island, Inscription Rock stands as a monument to the Indians once frequenting the area. Carved in 1625 by the Erie Indians, the rock is now partially protected by a wooden roof erected by the Ohio Historical Society. The pictographs depicting the annihilation of the Erie tribe by the Iroquois are now barely visible.

For years people were attracted to Middle Bass Island by the facilities and unique atmosphere afforded by the Lonz Winery. With the closing of the winery in 1975/76, few tourists make the trip to Middle Bass Island.

On the mainland, Catawba Island and the Marblehead area are popular sightseeing areas with well developed tourist sites. The Catawba Cliffs provide a scenic ride for cyclists as well as a point of interest

to those involved in local history and legend. The 150 year-old Mon Ami Winery still operates at the south end of the Island, offering tours through the wine cellar as well as an excellent restaurant. Marblehead offers a scenic drive around the quarries and one of the oldest lighthouses on the Great Lakes.

Johnson Island in Sandusky Bay is the site of the Confederate Civil War Cemetary. The Cemetary is the only area on the island open to the public and public access is by boat only.

Sunbathing. Beach areas for sunbathing are extremely limited. As a result sunbathers are most commonly seen on boat decks, lawns, and rocky cliffs. Few visitors come to the island region with the primary intention of sunbathing.

Swimming. Better water quality results in clearer water in the islands proper than near the adjacent mainland. The beach area along the north shore of Kelleys Island is the principal swimming area in the island region. In recent years high lake levels during the summer months have severely limited swimming and associated water-related activities at East Harbor State Park on Marblehead Peninsula. The only sand beach area on South Bass Island is a 30-yard area next to the grounds of Perry's Monument. This area is maintained by the village of Put-in-Bay. It is unguarded and is not used extensively. The unguarded cobble beach area at South Bass Island State Park is sometimes used by campers although swimming is discouraged by park officials. Swimmers frequently use selected areas of the rocky cliffs along the west shore of South Bass Island, often to the consternation of property owners. Sand beaches exist on the north shore of Middle Bass Island and on the southeast corner of North Bass Island. These beaches are not well known and are used infrequently for swimming activities.

SCUBA diving. The turbid waters of Lake Erie are not favored by SCUBA divers. In the island region, a few shipwrecks and sunken pleasure craft attract cottage dwellers and occasional visitors with SCUBA training.

Spring

Fishing. During the spring season, the island region attracts perch fishermen to the reefs. More important, during the month of May considerable numbers of anglers fish the nearshore zone of the islands in pursuit of smallbouth bass.

Sightseeing. Sightseeing during the spring is largely limited to school groups visiting Crystal Cave, Perry's Monument and the Ohio Division of Wildlife Fish Hatchery.

Fall

Fishing. The reefs and nearshore areas of the island region continue to attract anglers through the month of October. The number of anglers is considerably reduced from the summer period. The fish of choice during this period is perch, and to a lesser extent, smallmouth bass and walleye.

Hunting. The opening of the pheasant season in November attracts dozens of hunters daily to each of the larger islands. Small private hunts are arranged on Rattlesnake Island. The islands provide some of the finest habitat for pheasants in Ohio. The shortage of areas open to public hunting severely restricts hunters who have not made prior arrangements with local landowners. This shortage of available public areas results in a period of considerable disturbance and abuse of private property.

Winter

Ice boating. Several local residents own small ice sailing boats and utilize their recreational craft during periods when the frozen lake is free of snow cover.

Ice fishing. The Lake Erie islands, including Sandusky Bay, are the focal point of ice fishing activity for this hardy breed of Ohio angler. Locally, ice fishing is the focus of much activity in the local communities. Several island residents supplement their annual income by serving as ice fishing guides. Ice fishing guides provide transportation, shanties and bait to day-visitors at fees ranging from $6 to $12/day. Guides are busiest on weekends.

The number and location of shanties were surveyed during this study (Appendix C). During the 1976-1977 season, transient anglers caught approximately 21,000 yellow perch in the vicinity of the Bass Islands (D. Hair, Ohio Division of Wildlife, personal communication). A survey of ice fishing guides indicates the principal points of origin of transient anglers are the metropolitan areas of Cleveland, Columbus, Cincinnati/Dayton and Toledo.

Ice skating and sledding. During the period of ice cover, ice skating and sledding are the principal outdoor recreation pursuits of local young people.

Snowmobiling. Snowmobiles are not common in the island region. During severe winters, snowmobiles serve as valuable means of transportation on the more remote islands where snow removal equipment if limited. In addition, snowmobiles provide transportation between islands over the ice.

RESOURCE ANALYSIS OF THE LAKE ERIE ISLAND REGION

Aspects of the Island Experience

As defined, the coastal zone is a narrow region, existing as the edge between two quite different and complementary environments. It provides a set of resources unavailable on either land or water alone. Throughout, the coastal zone is under pressure for many uses, industrial and commercial, on the one hand, and recreational on the other. Islands, especially, are areas having increased demands for recreational facilities, second-homes and various associated supporting services.

Islands provide an esthetic experience that is conducive to recreational pursuits and vacation retreats. It is the shoreline in particular that is the focal point of these activities. Rocky cliffs, beaches, quaint cottages and the ever-changing condition of the water itself, from placid to stormy, all provide important and desired attributes. The esthetic force of water seems to be just as strong whether the activity involved depends directly on water for participation or is simply enhanced by its nearness (Carls, in Harper & Warbach, 1976). The islands are unique in that they are removed from easy access and the main body of human activity.

Uniqueness indicates the paucity of similar zones exhibiting the same elements as that under inspection. The relative scarcity or "uniqueness" of an esthetic quality is of increasing importance and value to society. The rationale that underlies this description of the islands is that: "landscape that is unique either in a positive or a negative way is of more significance than one that is common" (Leopold, 1969). The unique attraction of islands is their detachment both from the mainland and from mainland routine. Crossing water to reach land becomes a symbolic act of leaving behind too familar activities and unsolved problems (Islands of America, 1970).

Islands in general constitute some of the nation's finest reservoirs of unspoiled land. In the Ohio coastal zone, the islands contain some of the best remaining natural resources for recreation and other public use. Ohio's islands include over 6000 acres of land with vineyards, open fields and some scrub growth that is steadily succumbing to the

infringement of summer homes. This is especially true of the more accessible islands, principally South Bass, Middle Bass and Kelleys Islands. Outside of South Bass Island and Kelleys Island, the others are relatively unknown and unavailable for public use. Island land values are high. It is important to consider that once an island's remoteness or inaccessibility is reduced, it is drastically changed. Once developed, it is nearly imoossible to retain all the esthetic qualities which contribute to its unique desirability as a retreat.

Crowding and development are major points of concern in the coastal zone. Recreational resources are best and most meaningful at the land/water interface where they are most limited. In this interface area, resources are better measured in terms of length of the resource zone than in terms of overall area. Of Ohio's 262 miles of Lake Erie shoreline, approximately 37 miles is island shoreline. Island shoreline is the least crowded and least developed, with the exception of marshland, in the Ohio coastal zone. That portion of the Ohio shoreline from Conneaut west to Vermilion is almost completely developed. The competition for shore line use in urban/suburban communities has resulted in considerable pressure on available bathing beaches, boating and associated facilities. Equally important, development of supporting facilities often detracts from the natural character of the coastal zone.

The most heavily used public beach facilities in the U.S. are within a two hour drive of an urban area (Outdoor Recreational Resources Review Commission No. 4, 1962). Four urban centers (Cleveland, Detroit, Lorain/Elyria, Toledo) with populations totaling over seven million are at or within a 50 mile radius of Ohio's Lake Erie Islands. Along most of Ohio's shoreline, sites for new state recreational areas are nonexistent. The islands represent a significant percentage of the relatively undeveloped, esthetically fulfilling shoreline.

Between 1965 and 2000, the demand for outdoor recreation was predicted to increase 2-1/2 times. Growth was predicted to be even more dramatic in those activities for which islands are best suited: swimming, picnicking, boating, and fishing as well as hiking, camping, and nature study (Islands of America, 1970). A 1973 statewide survey of Ohio residents resulted in forecasts of outdoor recreation demand between 1975 and 1980. Of the 18 outdoor recreation activities surveyed, swimming, fishing, picnicking, and boating were ranked in order with the highest 1975 household participation rates (Outdoor Recreation for Ohio. 1975-1980 Executive Summary. Statewide Comprehensive Outdoor Recreation Plan, ODNR, 1975).

The growing demand for coastal zone and water-based recreational opportunities indicates a need for planning and managing with the goal of protecting existing island resources. Planners and managers should consider the effect of crowding and development on the nature and quality

of the recreational experience in an island environment. The Lake Erie Islands currently serve, in part, in the legendary role as places of escape and as sanctuaries for recreation and renewal. It is this esthetic experience provided by an island visit that is especially vulnerable.

Crowding and development apparently have a variable effect on a recreational experience. Development which conforms to those uses for which an area is best suited does not reduce preference for the area in any consistent manner. In an island environment, hiking trails, boating facilities, picnic tables, points which offer scenic vistas, etc., often enhance an area. Major departures from the natural landscape and developments that do not conform with the best uses of an area play a major role in reducing its desirability. The absence of people in an area should not always be considered a desired condition. The need for personal space during an island visit varies from time to time, location to location and person to person (Carls, in Harper and Warbach, 1976).

Carls (loc. cit.) cites growing evidence that esthetic factors, such as the number of people sharing a coastal zone development, have an important influence on use of the area. People tend to select those places with lower levels of crowding and development. At present, South Bass Island and Kelleys Island suffer from crowding during the holiday periods of Memorial Day, the Fourth of July and Labor Day as well as during the ILYA Regatta. During these periods of high use, visitors produce a considerable strain on local facilities and result in local enterprises and governmental agencies controlling access to the islands, restricting visitor activities and instituting reservation requirements, often in a seemingly uncoordinated and haphazard manner. During these periods, crowded conditions and the holiday atmosphere are considered an attribute by many, but not all, island visitors.

The recreational value of a small island, i.e., ten acres or less in size, varies according to the different experiences it produces in those who use it. This experience might well be termed the "island aspect" (Baldwin, 1964). This "island aspect" is a unique awareness or knowledge of being surrounded by water. This awareness derives from the special effort required to reach the island, an effect quite different from the more commonplace modes of driving or walking. In addition, the awareness of the nearness of water brought about by seeing water on all sides contributes to the unique experience derived from a visit to a small island. The "island aspect" is largely lacking on the larger islands of Kelleys, Middle Bass and South Bass.

Equally important, vistas of undeveloped islands in the vicinity of a more extensively developed region offer the promise of the new and unexplored to the viewer. Green and Mouse Island are undeveloped. These islands serve as harbingers which emphasize the sense of the remote and the inaccessible in people utilizing the Bass Islands as an area of retreat.

Living on an island for any period of time almost always results in the development of a unique sense of belonging. The isolated geographical situation results in frequent contact with other residents. This frequent contact with familiar faces produces a genuine sense of community. Local residents become quite familar with the activity patterns of their fellow island dwellers. The sense of community is well developed among cottage owners who are seasonal or occasional residents at best.

Most cottage owners reside in large metropolitan areas where personal relationships with neighbors may be limited or entirely lacking. Metropolitan area dwellers frequently maintain friendships over a relatively large geographic area. Quite often, interaction with service people, such as clerks, merchants, etc. is impersonal. The opposite of these observations is true in an island community. Cottage owners frequently state that they feel more a part of the island community than they do of their area of permanent residence. This feeling is equally strong among the children of cottage owners.

Local island residents express a strong bond of allegiance with most cottage owners. Cottage owners support the local community in several tangible ways. Development of the islands in terms of pleasant cottages provides each of the large islands with sufficient tax base to support a local school system with an independent school board. The large influx of tax dollars from outside the local community results in a local tax millage much lower than otherwise possible. Local residents are acutely aware of this fact. Any governmental effort to remove property from the tax base, especially property owned by cottage dwellers who support the community as tax payers and service customers will be met with local opposition. The boat lines which serve the island region are supported in the spring and fall largely by cottage owners visiting their property. In general, the operators of these services are opposed to any governmental plan or action which proposes to buy and eliminate island cottages. These operators are convinced such action will detrimentally affect their profit-making potential during their most vulnerable period. Potentially, the loss of a sufficient number of cottage owners due to public acquisition of their land could result in curtailed ferry service.

Critical Areas

In the island region, several sites including prime agricultural land, commercial mineral strata, hazardous geological formations, natural areas and wetlands have been identified as "critical" areas. Due to their scarcity or economic value, combined with the lack of protection now afforded these vulnerable areas, the Ohio Department of Natural Resources is committed to guiding the management of areas deemed of critical importance to a local community or to the people of the State of Ohio at large. In a few instances, sites of regional interest extending beyond the borders of the State of Ohio, have been identified in this report.

The extended growing season with its lengthy frost-free period provides the island region with the proper climatological conditions for viticulture and orchards. Unfortunately, this prime agricultural land occurs in an area in considerable demand for summer home and resort development. The value of such land as orchard or vineyard pales before its value as sites for commercial or residential development. Resort development has resulted in the loss of considerable orchard acreage on Catawba Island. The importance of the orchards and vineyards is considerable on a statewide basis. Thousands of people travel to the island region each year with the specific intention of sampling locally produced fruit and wine. In addition, the Isle St. George label of Meier's Wine Co. identifies wine produced by North Bass Island vineyards and marketed nationally.

An extensive portion of Kelleys Island and a small portion of Johnson Island have been developed as commercial mineral sources, i.e., limestone quarries. Quarry activity ceased on Kelleys Island in 1975. The quarry on Johnson Island has not been in commercial production for many years. The potential for further development of the Kelleys Island site is considerable. Further development is dependent on demand and favorable economic conditions. The Kelleys Island quarries are of potential importance to enterprises requiring large volumes of stone. Water transport is the only economically feasible method of delivering this high volume, low-unit price material. It is particularly attractive for shoreline construction.

The celestite crystals forming the floor of Crystal Cave on South Bass Island were sold for use as fireworks ingredients soon after the discovery of the cave. Subsequently, the site has been effectively developed as a tourist attraction. The importance of this unique geological formation as a natural phenomenon is national in scale. Development of Crystal Cave as a commercial mineral site is most unlikely under current ownership.

Nineteen of the natural areas identified in the island area are of local interest. Although attractive for the most part, these sites are not focal points of statewide interest although they are very important in the composition of an aesthetically pleasing island setting. Eleven natural areas are considered of statewide interest. Of the latter, four sites, including the mineral formation of Crystal Cave, are considered of regional and/or national interest. These natural areas are summarized in Table 63.

Ten wetland areas occur in the islands. The extent and nature of these wetlands is summarized in Table 64. Although the wetlands in the islands are small in comparison with the marshes of the Erie, Ottawa and Lucas County mainland, they must be considered to have statewide importance. Due to their ease of development, three have been effectively destroyed as wetlands. The latter currently exist only as marina boat basins.

Special Attributes

Within the island region are a diversity of points of interest - people, places, things - which are both unusual in their own right and uncommon on either a local, statewide or regional basis. The points of interest with special attributes identified during this study are summarized in Table 65. Eleven of the 33 points of interest are known to and utilized by local residents. The remaining 22 points compose a constellation of attributes which single out the island area as a focal point for Ohio citizens in search of the unusual within moderate distance.

Locally, Catawba Cliffs Drive is an impressive scenic drive along a high promontory along the west side of Catawba Island. The Johnson Island causeway is the only bridge connecting an Erie Island with a mainland point. The Colonial Hall in the village of Put-in-Bay serves as a focal point of community activity during the winter months. During this period, many local residents participate as members of one or more bowling teams. The winter leagues use the Colonial Lanes, the only bowling lane in the island area. The Golden Pheasant Inn on Rattlesnake Island provides a small resort facility with an intimate, remote atmosphere. Although not well known, the Golden Pheasant Inn caters to cottage owners and local residents of Middle Bass and South Bass Island. The Kelley Mansion on Kelleys Island is used as a local community center. The Dollar and Miller Mansions on South Bass Island are private dwelling constructed in the grandiose manner of the late 1800's.

TABLE 63

NATURAL AREAS IN THE LAKE ERIE ISLANDS REGION

	ISLAND	IMPORTANCE		
		LOCAL	STATEWIDE	REGIONAL
BEDROCK FEATURES				
Shore Cliffs	Catawba		X	
	South Bass		X	
	Gibraltar		X	
	Rattlesnake	X		
Glacial Grooves	Kelleys		X	X
	South Bass	X		
	Gibraltar	X		
	Catawba	X		
Caves	South Bass		X	X
	Catawba	X		
Mineral Formations	South Bass		X	X
	Green	X		
	West Sister	X		
Fossils	Kelleys		X	
	Johnson	X		
Virgin Island	Green		X	
	West Sister		X	X
	Mouse		X	
WETLANDS				
Fox's Marsh	North Bass		X	
Carp Pond	Kelleys		X	
Smith's Pond	North Bass		X	
Terwilliger's Pond	South Bass		X	
Haunck's Pond	Middle Bass		X	
WOODLANDS				
Victory Woods	South Bass		X	
Lighthouse Woods	South Bass	X		
OSU Wildlife Sanctuary	South Bass	X		
Duff's Woods	South Bass	X		
State Reserve	Kelleys	X		
Rattlesnake	Rattlesnake	X		
Marsh Woods	North Bass	X		

TABLE 64

WETLANDS IN THE LAKE ERIE ISLAND REGION

NAME	ISLAND	AREA 1900 (acres)	AREA 1977 (acres)	ORIGIN	PRESENT USE	NATURAL AESTHETIC RANKING[1]
1. Terwilliger's Pond	South Bass	4	4	Bedrock scour	Natural education area	7
2. Armbruster's Marsh	South Bass	0	2	Man excavation	Natural education area	5
3. Monument Marsh	South Bass	5	0	Isthmus bars	Filled, historic memorial	1
4. Fischer's Pond (Burgundy Bay Marina)	Middle Bass	8	3	Barrier bay	Marina, resort development	3
5. Haunck's Pond	Middle Bass	5	5	Isthmus bars	Natural area (former solid waste disposal site)	6
6. Wehrle's Pond (Lonz Marina)	Middle Bass	10	7	Barrier bar	Marina (abandoned)	2
7. Fox's Marsh	North Bass	10	10	Baymouth bar	Natural area	10
8. Smith's Pond	North Bass	5	5	Barrier bar	Natural area	8
9. Carp Pond (North Pond)	Kelleys	8	8	Baymouth bar	Natural area (State Park)	9
10. Kelleys Pond (Seaway Marina)	Kelleys	25	10	Barrier bar	Marina (partially abandoned)	2
	TOTAL	80	54			

[1] Ten (10) being most naturally pleasing; 1 being the most highly disturbed.

TABLE 65

SPECIAL ATTRIBUTES OF THE LAKE ERIE ISLAND REGION

FEATURE	IMPORTANCE		
	LOCAL	STATEWIDE	REGIONAL
1. Archeological sites (Kelleys Isl.)		X	
2. Catawba Cliffs scenic road	X		
3. Causeway (Johnson Island)	X		
4. Colonial Hall (Put-in-Bay)	X		
5. Confederate Cemetery		X	X
6. Crystal Cave (South Bass Island)		X	X
7. Fish Hatchery (South Bass Island)		X	
8. F. T. Stone Laboratory/Cooke's Castle		X	X
9. Glacial Grooves (Kelleys Island)		X	X
10. Golden Pheasant Inn (Rattlesnake Isl.)	X		
11. Historical aircraft (Ford Tri-Motor)		X	X
12. Historical mansions	X		
13. Historical ruins (wineries & hotels)	X	X	
14. Ice fishing		X	
15. ILYA Regatta (Put-in-Bay)		X	X
16. Inscription Rock (Kelleys Island)		X	X
17. Inter-island ferry boats		X	
18. Lighthouses		X	
19. Limestone quarries	X		
20. Ohio State Music Camp		X	
21. Perry's Lookout (Gibraltar Isl.)	X		
22. Perry's Victory & Intern. Peace Mem.		X	X
23. Put-in-Bay harbor		X	X
24. Put-in-Bay village		X	X
25. Rare salamander (North Bass Island)		X	
26. Rare snail (Green Island)		X	
27. Rattlesnake Island postage stamps		X	X
28. Reef fishing		X	
29. School systems		X	
30. SCUBA diving, shipwrecks	X		
31. Table Rock (Kelleys Island)	X		
32. Turtle Island	X		
33. Wineries and vineyards		X	

The winery ruins on Kelleys Island, the Lonz Winery Building on Middle Bass and the foundation ruins of the Victory Hotel on South Bass Island are points of interest to those who acquire a knowledge of the history of the islands. The limestone quarries on Kelley's Island are a point of local interest for future economic utilization. Perry's Lookout on Gibraltar Island is a high vantage point providing a fine vista of the Bass Islands to Ohio State University students attending Stone Laboratory. Several sunken vessels in the area are examined by local SCUBA diving enthsiasts, principally cottage dwellers. Table Rock on the northeast point of Kelleys Island is a scenic outlier attracting local interest.

Turtle Island in Maumee Bay, has had a comparitively large history for such a small island. Residents of the Toledo area seem to place a special importance on Turtle Island both for its role in local history and for personal memories of visits to the island. When the island is mentioned in local newspaper accounts, it is usually in reference to fishing or picnicking trips. Most Ohio residents have never heard of Turtle Island. Its importance for the citizens of the State of Ohio rests with the role marking the boundary between Michigan and Ohio.

A number of island attributes are of limited local interest but of considerable importance on a statewide/regional basis to special interest groups. Among these are the archeological sites on Kelleys Island and the Confederate Officer's Cemetery on Johnson Island. Stone Laboratory on Gibraltar Island is the oldest freshwater biological station in the United States. A diversity of students and visiting scientists utilize its facilities during the summer months. Ice fishing activity attracts hardy sportsman from throughout the state during the months of January and February. During the summer months, reef fishing again attracts these sportsmen. The Interlake Yachting Associations Annual Regatta attracts sailing enthusiasts and a diversity of sailing vessels each August. Put-in-Bay Harbor provides a focal point of interest to power boat enthusiasts based in Cleveland, Catawba-Marblehead, Toledo and Detroit. The Ohio State Music Camp held on South Bass Island each summer attracts talented high-school age performers from across the state. The intensive learning experience provided each camp group culminates with a recital performance open to the public. Local residents and cottage owners provide large and receptive audiences.

The snail, Anguispira kochi strontiana, is unique to Green Island. This is the only known habitat for this subspecies. North Bass Island provides habitat for a rare population of triploid salamanders, Ambystoma texanum.

Over 2000 philatelists subscribe to the annual Rattlesnake Island issue.

A number of attributes of the island region are of broad interest and general appeal. Large numbers of visitors tour Crystal Cave, Hineman's Winery, the Ohio State Fish Hatchery, Perry's Cave, Perry's Monument, and the Village of Put-in-Bay on South Bass Island. Considerable numbers visit the Glacial Grooves area and Inscription Rock on Kelleys Island. Most visitors are enthusiastic about the opportunity to ride aboard one of the ferry boats serving the islands or to fly to South Bass Island aboard the Ford Tri-motor Aircraft. The lighthouse structures on South Bass Island and at Marblehead Point add a romantic aura to the island region, and serve as points of interest for many visitors.

Many visitors question local residents about the local school systems. The obvious remoteness of the island situation combined with the small permanent population serve as topics of intrigue. The fact that such small independent school systems continue to function in the state is met with amazement and occasional disbelief.

RECOMMENDATIONS

The U.S. Department of Interior, Bureau of Outdoor Recreation's (1970) publication ISLANDS OF AMERICA provides an important overview of policies and recommendations that serves as the framework for the recommendations of this study. Two major goals were recognized as necessary to protect America's islands:

1) public control of representative island areas sufficient to meet public recreation, scenic, wilderness, historic and scientific needs.

2) restoration and maintenance of the environmental quality of all American islands.

Concerted action in the public and private sectors both locally and statewide are necessary to achieve these goals. The Lake Erie islands are important assets to the recreation and scenic resources of the State of Ohio. These island resources are especially vulnerable to unwise development practices. Specific considerations outlined in the federal report are considered below:

State Actions

1. Include specific analysis of the Lake Erie Islands in the comprehensive statewide outdoor recreation plan.

The Land and Water Conservation Fund Act (P.L. 88-578) provides for matching grants to the states, and through them the local governments, for the purchase and development of outdoor public recreation areas. Funding is also available through Sect. 315.2 of the Coastal Zone Management Act of 1972. In this context, a recreation potential exists for Turtle Island in Maumee Bay as a stopping place for boating enthusiasts and as a local historic site. The acquisition and development of Turtle Island and its integration into Maumee Bay State Park is recommended.

2. Title to State-owned islands should be perfected to protect and develop those with recreation and related values.

The State of Ohio currently holds title to Gibralter Island and Green Island, as well as portions of Kelleys Island and South Bass Island.

3. Provide statewide zoning for island conservation. Underwater protective zones around islands selected for public recreation should be established.

The reefs of the island region are intensively fished by Ohio anglers during the spring, summer, and fall months. Protection of these sites should be ensured.

4. Enforce regulations to control dredging and filling.

Dredging and filling activities destroy natural features, reduce recreation space, and reduce fish and wildlife habitat. In recent years, several island wetlands have been lost as natural features and as fish and wildlife habitats in favor of their development for recreation, i.e. marina space.

5. Recreation use or potential of islands should be considered only within the limits of State standards and regulations governing water quality.

Sewage pollution from recreation vessels and faulty or inadequate septic systems is a continuing problem in the island area.

6. Acquire or otherwise obtain public access to islands suitable for recreation and conservation purposes.

   a. The U.S. Bureau of Outdoor Recreation recommended the following action: "State acquisition of several sites on North, South and Middle Bass Islands, and Kelleys (sic) Island for small craft harbors and adjoining recreation areas. The local government and private sector should be joint guardians of the scenic values on these islands (U.S. Department of Interior, 1970)."

The development of large private marina facilities on Kelleys Island and Middle Bass Island have been failures or only marginally successful to date.

b. Small islands are of greatest value if kept in their natural condition (Baldwin, 1965). This report emphasizes the importance of Green Island, Mouse Island, and Starve Island in enhancing the appearance of the island region. The vista provided by these islands contributes to scenic values of the larger islands and the adjacent mainland area. It is recommended that Mouse and Starve Islands be acquired by the State of Ohio and maintained in their natural condition as much as is possible. Failing acquisition, the use of conservation or scenic easements, zoning, custodial arrangements, and other protective measures should be explored with island owners, semi-public, charitable, private or other groups interested in the preservation of the natural beauty of these islands. A "scenic easement" provides that the island be kept perpetually in a natural state. Easements cost the taxpayer nothing, preserves the island and protects the owner from excess taxation (Baldwin, 1965). In addition, Green Island should be designated as an area of special interest for ecological research.

c. The funding of one or more workshops designed to provide access for island businessmen to expertise of individuals concerned with recreation on a regional and statewide basis. Topics for such a workshop should include pricing and financial management, market growth, local resource base and promotional-political-organizational aspect of successful recreation businesses (Minahan, 1976).

Local Action

1. Adopt long-range plans, backed by effective zoning and other necessary ordinances, to conserve island resources.

The large islands and several small ones are already occupied by camps, cottages, and other developments, all of which are similar to developed shorefront property. Public interest is the same for all shoreline uses-attractive development, good sanitation, and proper consideration for good use of land and bordering water areas (Baldwin, 1965). Local planning and ordinances should emphasize these values.

2. Acquire island property for recreation, open space, and conservation.

3. Assure public access to shorelines by acquisition, purchase of easements, tax incentives, and by other means.

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